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ABSTRACT

The study was prepared, at the request of UNESCO, by the European Federation of National Associations of Engineers (FEANI), an organization grouping the engineering associations of 18 countries and including 650,000 engineers. The differences in the types of engineering programs and graduation requirements of the various countries are examined, along with the differences in terminology and definitions used in the engineering education systems. The qualifications for becoming a professional engineer and the standards of engineering societies are reported, in addition to the role of the engineer in the industry of each particular country. The report concludes with an examination of the common denominators of the Continental and the British engineering education systems and discusses the possibilities of applying the European experiment of FEANI to other continents. (MLH)

Standards for engineering qualifications

A comparative study in eighteen European countries

The Unesco Press

Titles in this series

1. Standards for engineering qualifications
2. Social sciences and humanities in engineering education
3. The continuing education of engineers

Standards for engineering qualifications

A comparative study in eighteen European countries

Prepared by the General Secretariat of the European Federation of National Associations of Engineers (FEANI)

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Preface

The possession of a sufficient stock of highly qualified scientists and technologists is increasingly recognized as one of the essential pre-conditions for national economic and social development. However, science and technology are advancing so rapidly that many countries encounter serious problems in their efforts to educate and train such personnel, and this is especially true of engineers.

As a contribution to the solution of this problem, the General Conference of Unesco, at its sixteenth session, authorized the carrying out of case studies on basic standards in engineering education. At the same session, work on licensing and registration controls in the engineering profession was also authorized. The publication of a series of studies on the education of engineers was undertaken within the programme of work thus defined by the General Conference.

The studies should not be regarded as exhaustive, nor should the reader expect to find in them definitive solutions to particular problems. Rather, it is hoped that the discussion of some present-day topics in engineering education and training, and the bringing together of comparative information from many countries in these volumes will lead to reflection and innovation.

The present work is devoted to standards for engineering qualifications. In recent years there has been widespread discussion, particularly in Europe, on this subject. The close economic and social integration of countries of the European Economic Community has been one factor in promoting this reappraisal, especially as it relates to the free movement of workers. The problems associated with the mutual recognition of engineering qualifications are still being resolved, and the recent enlargement of the Community has added a further dimension to the debate.

The standard of engineering qualifications has also become an important issue within some European countries, where major changes in the structure of higher technical education have been made or are proposed, as in France, the Federal Republic of Germany and in Spain. One important trend has been towards the creation of new courses and qualifications at the level of technologist or technician engineer, in a wide variety of fields.

The identification of basic standards in engineering education, now of topical concern in Europe, is also of interest to many other countries whose systems of engineering education were originally based on those in Europe. Furthermore, efforts to establish regional agreements for the mutual recognition of engineering qualifications are being made in several regions outside Europe, and thus discussion of progress being made in Europe is of value to these other regions.

This study was prepared, at the request of Unesco, by the European Federation of National Associations of Engineers (FEANI). The federation was formed in 1951 and now groups the engineering associations of eighteen countries, representing a total of 650,000 engineers.

FEANI's activities in the field of professional education and training include the work of its specialized committee on training as well as the series of meetings which the federation has held on training matters, including the joint Unesco/FEANI seminar in Helsinki in 1972 which is the subject of another volume in this series.

The opinions expressed in the study are, of course, not necessarily those of Unesco, and the Organization is not responsible for the choice and presentation of the facts used to support or illustrate the ideas put forward.

Unesco wishes to thank all those who have contributed to this study, and particularly Professor Broida and the members of the secretariat of FEANI, whose contribution was substantial and whose ready co-operation has been greatly appreciated.

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Foreword

This report on a highly complex matter is the work of a team, the individual participation of each of whose members deserves special mention.

I should like first to thank my predecessor, Colonel Georges Clogenson Ingénieur Diplômé, of the Ecole Polytechnique, now consultant to and honorary member of FEANI who, after establishing the broad lines of this study and supervising the design of a questionnaire addressed to the national associations, members of FEANI, gave us the invaluable benefit of his long experience during the critical examination of the first draft.

My thanks go next to the eighteen national associations, members of FEANI, all of which replied, in greater or lesser detail but with the same willingness, to the questionnaire addressed to them by the then Secretary-General. Summaries of their replies (with comments where necessary) are given in the Appendix to this report.

I should like to thank especially my two closest collaborators. General Yves Mottez, Ingénieur Civil, Ecole Nationale Supérieure des Mines, Paris, who drafted the original text of Chapter 2 and took part in finalizing this study as a whole, and General Robert Bureau, Ingénieur Civil, University of Louvain, who contributed many important additions and constructive suggestions to the original text of this report, drafted by myself except for Chapter 2.

We received substantial assistance from outside FEANI. that of Pierre Bailly, former Secretary-General of France-Intex, who contributed his valuable experience in all matters relating to the qualifications of technicians and senior technicians.

Lastly, despite the traditional discretion which always surrounds the work of the Unesco Secretariat, I cannot forbear to stress how constant was the kindness, and at the same time how well-informed and constructive the advice I received, both at the preliminary stage of establishing the programme for this study and at the stage of the joint critical examination of the first draft, the final shape of which is largely due to the Unesco Secretariat.

Professor Victor Broida,
Docteur-Ingénieur,
Secretary-General of FEANI

1 Introduction

1.1 Difficulties of terminology and definition

According to the context, the term 'engineer' brings to mind either of two completely different interpretations. (a) that of the holder of a diploma of higher technical education—that is, the qualification of engineer, or (b) that of a person occupying an engineering post in industry—in other words the function of engineer.

In fact, there is at times only a somewhat loose direct connexion between the qualification of engineer and the functions actually performed.

In the first place, not all of those who successfully complete a higher technical course leading to an engineering qualification devote the whole of their professional careers to engineering. Is there a technical, university or technical college which does not count tradesman, clergymen, rural landowners, artists, etc., among its former students?

Then, in many countries the right to call oneself an engineer is not regulated by law, and anyone may do so without running the risk of legal action. This does not mean that a man may with impunity claim to be a qualified engineer of a particular university or higher technological institution which in fact he has never attended, or has left before qualifying.

However, apart from the question of the possible misuse of an engineering qualification—which is, after all, exceptional—there are many people in industry who perform the functions of an engineer without ever having obtained an engineering qualification on leaving university, technical college or a State-recognized institution. These are people who have acquired equivalent skills elsewhere than at a university or higher technological institution, often as the result of considerable personal effort. In some countries these non-qualified engineers may acquire a certificate from a State-recognized institution testifying to their aptitude.

On the other hand, there are people who have acquired neither an engineering qualification nor the equivalent skills, but who make up for this lack to some extent by a thorough inside knowledge of the particular firm for which they work, its special techniques, practices and 'climate'.

The basic difference between a non-qualified engineer and these latter people emerges clearly when one of them prepares to leave the firm which has been employing him to join another firm. The non qualified engineer, even if he is sometimes handicapped in looking for new employment by the absence of a diploma, does eventually find it, thanks to his skills which are equivalent to those of a qualified engineer, but the person who has lost

his main asset, namely his thorough knowledge of the inside workings of a particular firm which he is about to leave, is heavily handicapped by his inadequate general knowledge of the engineering profession, an inadequacy which he had thus far succeeded in offsetting.

Two questions arise immediately concerning engineering qualification standards.

The first, relating to qualified engineers, is as follows. which are the institutions whose diplomas can really be deemed to confer the qualification of engineer, and which are those whose diplomas should be regarded rather as conferring a technical qualification in a different category from that of a qualified engineer? The same question might be put in a different way. where does the qualification of engineer begin, and where does it end?

This first question, at first sight very simple, is by no means so, in fact, because of the terminologies used by different countries to designate the product of an institution of higher technical education.

The same product, the result of roughly the same education, is called a 'technician engineer' in one country and a 'senior technician' in another, this might suggest that the former is an engineer and the latter not, whereas they have received a similar education.

This ambiguous usage is, moreover, coupled with another of like nature. Certain countries use the term 'engineer', sometimes with a qualification (e.g. 'civil engineer', 'technician engineer', '*Diplomingenieure*', 'graduate engineer', etc.) to describe people who have acquired different levels of education. To add to the complication, the term 'graduate engineer' is used in other countries to describe a professional technologist above a certain level who holds a degree recognized by the State.

These inconsistencies highlight the need to avoid relying unduly on the name given to a diploma, and to seek qualification standards or criteria which can be applied to different countries.

The second question, relating to non-graduate engineers, is as follows. where does the qualification of a non graduate engineer begin, and where does it end?

The complexity of this question is easy to grasp. Yet as early as 1951 Switzerland set up a national register which regulates the use of professional qualifications. This register is open to professionals who have passed a professional, i.e. non-academic, examination held in the actual conditions in which they exercise their profession. As for those who hold an academic qualification, they may be enrolled on the same register simply upon request and, naturally, without any preliminary examination other than submission of their credentials.

Another country, the United Kingdom, set up in 1964 a national registration system known as the Engineers' Registration Board (ERB). Substantially the same as the Swiss national register, the British national register nevertheless differs in spirit. For whereas in Switzerland the general rule is that a diploma is produced, the case of the non graduate being the exception, in the United Kingdom the academic standard required for admission as a chartered engineer (CEI), is, on the contrary, the Council of Engineering Institutions (CEI) examination, diplomas being accepted only if they qualify for exemption

from taking this examination. This will bring us later on to speak of the 'British system' (based on a professional examination, which is moreover a very difficult one), by contrast with the 'Continental system' (based on an academic diploma).

At the European level, it was only natural that an attempt should be made to find a practical solution to the very confused situation arising out of a great variety of national practices and legislations. This was essential in order to enable engineers from one country to settle in another.

FEANI began in 1954 to study the possibility of establishing a *European Register of Higher Technical Professions*, this international register was introduced gradually, and began to operate on 1 January 1970 for engineers and senior technicians seeking to leave their home countries.

It is largely on the basis of the experience thus gained by FEANI that we shall try to clarify the subject.

1.2 Conventional definitions adopted

The work of the European Economic Community (EEC) preparatory to the signing of the Treaty of Rome, linking Belgium, France, the Federal Republic of Germany, Italy, Luxembourg and the Netherlands (subsequently joined by Denmark, Ireland and the United Kingdom) included the establishment of three draft directives concerning engineers within the countries of the Community. Draft Directive No. 2 provides for three groups of standards qualifying for engagement in and the exercise of non-wage-earning activities in research, design, consultation and applications in the field of technology, articles 1, 2 and 3 respectively of this draft directive contain definitions which seem to be very clear.

We believe that a distinction should be drawn between the following three categories of technical professions:

Category C, roughly covering 'conception engineers'.[1] These are technologists who are accustomed to think in abstract terms, to take a synthetic view of events which are not obviously linked together and to demonstrate a sufficient degree of creativity, they also have, of course, a sufficient degree of practical knowledge in order to be realistic and not limit themselves to theoretical speculations.

Category L, roughly covering 'liaison engineers or senior technicians'. These are technologists who provide the link between 'conception engineers' (whose predominant competence is theory) and 'execution technicians' (whose predominant competence is practice). The 'liaison engineers or senior technicians' are, therefore, capable of understanding abstractions and of translating them into practical language, thus forming the essential bridge between the other two equally essential categories.

Category E, roughly covering 'execution technicians'. These are technologists who carry out and are responsible for the execution of projects

1. Neologisms introduced by the General Secretariat of FEANI for the sake of clarifying the respective attributions of the three proposed categories of technological professions.

initially conceived by the conception engineers' and then adapted to the practical realities of industry by liaison engineers or senior technicians'. Needless to say, the respective qualifications for the three categories of technical professions will be those which are necessary and sufficient for the full exercise of the functions defined above for each of these categories.

The working method adopted here will consist in defining these very general ideas in successive stages.

First, a comparison will be made between the criteria stemming from EEC Draft Directive No. 2, the FEANI *European Register of Higher Technical Professions*, and the British national register of the Engineers' Registration Board (ERB).

An attempt will then be made to deduce pragmatically from the views prevailing in the various European countries, a type of education and above all, criteria for qualifications, which should be considered as representative prototypes for each of the three categories C, L and E. These will be set out in Chapter 3 (Sections 3.3 and 3.4), (a) for category C, in connexion with the example of the Belgian *ingénieurs civils* and the German *Diplomingenieure*, (b) for category L, in connexion with the example of the Finnish engineers (as distinct from graduate engineers of the same country), (c) for category E, in connexion with the example of the British 'technicians'.

CATEGORY C (conception)

C-1. Definition in Article 1 of the EEC Draft Directive No. 2

A diploma awarded on successful completion of a full course of studies of at least four years taken at university in the discipline corresponding to the activity concerned.

A certificate attesting the actual performance of the activities concerned for at least two years after the award of the diploma.

C-2. Definition in section A of the FEANI European Register of Higher Technical Professions

Qualified engineers from schools providing a complete scientific and technological education at university level.

Admission to these schools is at the level of the examination giving access to university education.

C-3. Definition of 'chartered engineer' in the British national register of the ERB

Minimum age: 25.

A pass mark in the examination in applied science held by the Council of Engineering Institutions (CEI) in accordance with the council's regulations, or a pass mark in any other university examination or test accepted by CEI as being of at least equivalent level (the university level of the examinations and tests held or accepted by CEI is not less than that of the Degree in Engineering).

Practical training in the engineering profession, or functions which make it possible to acquire such training, meeting the practical training criteria established by the CEI member institution and complying with the general principles adopted by the CEI.

At least two years experience in a post considered by the CEI member institution to entail professional responsibility, provided that the total amount of the period of this professional

experience and the period of practical training referred to above is not less than three years

Comments on category C (conception)

C-1 and C-2 are much on the same lines as regards the level for admission, the length of education (at least four years of university education, including complete scientific and professional training) and its nature (university level).

C-1 innovates in comparison with C-2 in that it requires the actual performance of the activities in question for at least two years after passing the final examination.

System C-3 which at first sight appears to reflect a different approach, is in fact similar to C-1 and C-2 the length and nature of the education required are comparable with that for the Degree in Engineering. It should be noted that, as with C-1, two years' professional experience is required.

System C-3 seems to attach more importance to practical training. In some cases this may be only a superficial impression, since some continental countries include practical training during the period of university studies.

The nature of the education, which plays a great part in the qualification standards, will be illustrated by examples in Chapter 3, in particular as regards the Belgian *ingénieurs civils*.

CATEGORY L (liaison)

L-1. Definition in Article 2 of the EEC Draft Directive No. 2

A diploma awarded on successful completion of a full course of studies of at least three years at a higher technical institution in the field of study corresponding to the activity concerned.

This course should be preceded by the successful completion of at least twelve years education, including studies and practical training.

A certificate attesting the actual performance of the activities concerned for at least two years after passing the final examination.

L-2. Definition in the FEANI European Register of Higher Technical Professions

L-2.1: Definition in section Ab of the register

Graduates of schools that provide a less extensive but more practical scientific and technical education lasting at least three years.

Admission to these schools is at the same level as university entrance.

L-2.2. Definition in section Ba of the register

Graduates of a higher technical school providing a course of at least three years duration, and who have obtained a minimum of three years practical experience before, during or after the course.

Admission to these schools is at a lower level than the examination giving access to university, and the studies are generally mainly in specialized technical and scientific subjects with a practical bias.

L 3 Definition of technician engineer in the British national register of the ERB.

Minimum age 23.

Academic qualifications at a level at least equal to that of the Higher National Certificate or the City and Guilds Full Technological Certificate (four years part-time technical education) and approved by the Office of the ERB and CEI.

Five years minimum professional experience in the engineering profession two of which must have been spent on practical training both experience and training to be recognized by the Office of the ERB and CEI

Comments on category L (liaison)

Here the similarities between the systems are less obvious It should be borne in mind that the EEC system is still under discussion, that it has been devised comparatively recently and that it takes into account a fairly general trend in most countries with regard to education. This is not the case with the FEANI system devised some ten to fifteen years ago, which was based on practical experience of the situation at that time, and subsequent developments.

The admission requirements for L-1 are perhaps less stringent than for L-2.1. The opposite is true of L-2.2.

The length of studies and their practical bias are the same in both cases, but it is obvious that the L-2.1 education is more advanced than L-2 2

Briefly, the question is whether L-1, L-2.1 and L-2.2 all correspond to the general notion of liaison engineer or senior technician. It seems that the answer is in the affirmative.

There is no doubt that the differences due to the ways in which systems of education and training have developed will gradually disappear

It will be noted that, here too, L-1 innovates by introducing the criterion of the actual performance of the activities concerned for at least two years after leaving the educational institution.

It is fairly easy to draw a parallel between L-3 and L-1, though the former obviously attaches far greater importance to professional practice.

Also for category L, a specific example will be given as a prototype (see Sections 3 3 and 3.4) in connexion with the example of Finnish professional technologists in category L.

CATEGORY E (execution)

E-1. Definition in Article 3 of the EEC Draft Directive No. 2

A certificate attesting that the holder has completed at least thirteen years' education in a State-recognized technical school, including as a final stage a complete course of at least two years full-time technological education in the subjects corresponding to the activity concerned.

A certificate attesting the actual performance of the activities concerned for at least two years after completion of the technological education.

E-2 Definition in the FEANI European Register of Higher Technical Professions

For the time being there is no definition.

E-3 Definition of 'technician' in the British national register of the ERB

Minimum age 21.

Academic qualifications at a level at least equivalent to that of the Ordinary National Certificate or the City and Guilds Part II/Final Technicians Certificate (two or three

years part time technological education) and approved by the Office of the ERB and CEI (unless otherwise decided by the Office and CEI)

A minimum of three years experience in the technological field two years of which should have been spent on practical training recognized by the Office of the ERB and CEI

Comments on category E (execution)

The FEANI register, which is restricted to higher technical professions, stopped short of defining this category, though the possibility was contemplated

Draft Directive No 2 aimed at covering a wider range of professional technologists at a larger number of levels There is no basic contradiction between them

System E-3 fits in fairly well with E-1.

Examples will be given in Chapter 3 illustrating the education of professional technologists in this category (in particular, the example of the training of British technicians).

Of course, industry has as much need of execution technicians (category E) as of 'conception engineers' (category C) and particularly of liaison engineers or senior technicians' (category L), without whom collaboration between the two preceding categories would undoubtedly give rise to many difficulties.

Furthermore, divisions exist in many countries (to begin with, in the United Kingdom) which are identical or at least similar to the three categories C, L and E. In countries where this is not the case, the definitions of the three categories given above will make it easier to describe the real state of the divisions to be found in each of these countries taken separately, by noting how and where they differ from these three pre-defined categories.

In conclusion, it may be noted that the results of the studies undertaken by FEANI (dating back to 1954), the EEC (dating back to 1964) and the United Kingdom CEI (dating back to 1964) are in general agreement, except where there have been subsequent factual developments

1.3 Aims of the study and working methods

The present study has the twofold aim of (a) providing basic qualification standards for the categories of technological careers which we have just defined, and (b) providing criteria for evaluating education programmes for each of these categories

In order to have as a basis an up to date review of the situation in each country, the General Secretariat of FEANI sent out a detailed questionnaire to the national associations of its eighteen member countries

This questionnaire, dated 20 April 1972, was answered in varying degrees of detail by all the FEANI national associations, representing the following eighteen member countries Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Federal Republic of Germany, Greece, Ireland, Italy,

Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

In the following pages, an attempt will be made to answer the two questions raised above, concerning basic qualification standards and criteria for evaluating programmes, by presenting a chapter-by-chapter review of the replies, illustrated by the most typical examples from individual countries.

In addition to this general review, the reader will be given a conspectus of the present situation as it exists in each of the eighteen countries under consideration as well as an indication of the new trends To this end, eighteen national monographs, each devoted to a member country of FEANI, are given in the Appendix.

In concluding this Introduction, it should be stressed that both the various chapters forming the review part of this report, and the eighteen national monographs to be found in the Appendix, refer not only to the present situation in these countries in general and in the individual countries in particular, but also to the new trends which are emerging and to which reference will be made whenever necessary

2 The *European Register of Higher Technical Professions*

Freedom of movement for engineers is one of the chief objectives which FEANI has set itself In doing so, it has rapidly become involved in problems of education, and in order to deal with these it has found itself compelled to move ahead of the public authorities and to draw up a *European Register of Higher Technical Professions* at a professional level.

But reference to education in order to regulate exchanges of professionals, their freedom of movement and their right to settle outside their home countries, made it necessary to fix criteria for qualifications and over-all standards which would enable these professionals to be classified according to competence.

It should be noted that the fact that one is led to distinguish between different types of education does not imply a scale of values or the superiority of some professionals over others, the register booklet duly makes this point.

The register therefore lays down over-all standards in direct relation to the different types of education undergone by the various professionals whose capabilities meet the requirements of employers, and particularly of industrialists. These capabilities, as the register states, are determined initially by knowledge acquired in educational establishments, but are reinforced later by experience gained in actual practice of the profession. In addition to this experience the calibre of the individual must, of course, be taken into account.

As regards the academic knowledge to be measured by the over-all standards, one could say that it comprises a knowledge of concepts of pure science, as of applied science, often known as technical education, scientific and technical education may be combined in varying proportions according to the type of education concerned.

The register booklet, published in the three official languages of FEANI (French, German and English), gives the present-day structure of the register, this structure is not rigid.

The FEANI register is made up of two groups, A and B, which may in turn be divided into sections, professionals who have acquired the qualifications or attained the over all standards of education which correspond to these groups or sections may be entered in the register. In order to make this registration more effective in practice, the educational establishments have been classified and appear in an appendix to the booklet according to the type of education they provide. Possession of a diploma from an establishment recognized by FEANI automatically entitles the holder to be entered in the register.

It has been impossible to make such reference to the type of education given in the establishments which educate engineers and technicians in the case of the United Kingdom (which became a member of FEANI in 1965), since in the United Kingdom vocational education and training in the engineering field is based on a conception somewhat different from that existing on the Continent The idea of a diploma is replaced by that of qualifications or criteria justifying the right to bear the title as the British understand it, as has already been said in Chapter 1, these qualifications are determined by passing an examination, and they give considerable weight to the idea of practical training and the practice of the profession

A few details must now be given concerning groups A and B of the register

Establishments classified in group A recruit their students at the level of the final secondary-school examination, and provide scientific and technical education which is (a) comprehensive and at university level for section Aa, (b) shorter and more practical, with a minimum of three years of study, for section Ab.

Group B is composed of establishments which recruit their students at a lower level than that of the final secondary-school examination, and provide more specialized education with a practical bias, only section Ba exists at present, it comprises establishments which provide an educational course lasting at least three years, combined with three years of practice. Further sections may be added later but the register is at present confined to the higher technical professions

In addition to persons who hold a diploma granted under the circumstances described above, persons who can furnish proof of knowledge acquired independently by their own efforts, and of the standard required for the usual educational channels, are also eligible for registration. It is customary to call these people self-educated . Naturally, FEANI has made arrangements to check the qualifications of such candidates for entry in the register. These arrangements have made it possible, among other things, to incorporate into the continental system the British criteria for the definition of the various categories of professionals in the engineering field.

At the practical level, FEANI has adopted a decentralized system of operation for its register; this is obviously the best method of making it familiar, first of all to the nucleus of engineers or senior technicians, and then to arouse the greatest possible interest in it among the national members of FEANI Each member is then expected to form a national office of the European register, which, in observance of the rules set out in the booklet and the special measures taken by the Register Committee, is responsible for registrations. Nevertheless, at the FEANI level, the Register Committee continues to act simultaneously as a co-ordinating, supervisory and centralizing body for the results obtained by the various national offices, its sessions, which occupy a prominent position in the meetings of FEANI, are closely followed by the international organizations which are concerned with FEANI s work in this field, chiefly the European Economic Community (EEC) and the Organization for Economic Co-operation and Development (OECD), which regularly send representatives to the meetings.

The booklet entitled the *European Register of Higher Technical Professions*, together with its appendix, which has already been mentioned, are therefore the crystallization of FEANI s efforts towards achieving freedom of movement for engineers and technicians Following the first edition printed in 1965, a further edition in three languages was published in 1970, and the appendix was brought up to date in 1971

As has been said, the current edition is not final FEANI has no intention of taking up a static position, the difficulties which it has encountered, and is still encountering, are there as a reminder of this fact. It therefore seems necessary at this point to mention the most important of these difficulties.

First, while governments are on the whole in favour of FEANI's efforts, they do not seem to be in any hurry to adopt the co-ordinating measures which would make it much easier to put the register into effect, namely the finalizing of plans for the reorganization of higher technical education, standardization of the nomenclature for the various types of professionals, etc Even within FEANI, the results obtained since the register was launched on 1 January 1970 vary a great deal from one country to another. If in some countries the results are unimpressive, this is certainly due to wholly inadequate publicity. Those responsible are first and foremost the engineering associations, i e. the national members of FEANI, and in addition the public authorities, to the extent that they have been kept in the picture by the former

For the time being, the entering of professionals in the FEANI register is confined to candidates who wish to practise their profession in a country other than their home country This is a direct consequence of the essential task which FEANI has set itself freedom of movement for its professionals. It is also the outcome of a drive towards simplification which made it possible to adopt practical rules for the working of the register when the new edition of the booklet was published (1970).

The criteria chosen for registration have been described above. But although the rules set out appear simple in theory, this is not the case in practice, owing to the difficulties encountered, to which reference has already been made.

First of all, FEANI has to tackle nomenclature problems, which are further complicated by translation difficulties. For instance, the term professional engineer, used in the United Kingdom, has no exact equivalent on the Continent What follows has already been stated in Chapter 1, but it is worth repeating The word engineer does not have the same meaning in the different FEANI countries Whereas, in France, anyone can call himself an *ingénieur*, provided that this is not followed by the word *diplômé*', in Portugal and Italy there is an order of engineers, or its equivalent, and in Scandinavia the term engineer covers the whole range of highly qualified professional technologists The specific outcome of this state of affairs is that the professional, who has undergone education measuring up to well-defined over all standards, is called by a different name according to his country of origin for example, the terms non graduate engineer, technician engineer and senior technician seem to be almost interchangeable in a fair number of cases.

Table 1. Number of registrations in the FEANI register

Country	1970			1971			1972[1]		
	Group A	Group B	Total	Group A	Group B	Total	Group A	Group B	Total
Austria									
Belgium									...
Czechoslovakia									...
Denmark	62	87	149	26	134	160	19	74	93
Finland	5	14	19	3	13	16	1	11	12
France	14		14	8		8	5	...	5
Federal Republic of Germany								...	...
Greece								..	...
Ireland				1		1		..	...
Italy		..						...	...
Luxembourg								...	...
Netherlands							..	...	..
Norway		1	1	1	4	5	1	4	5
Portugal		..						...	..
Spain				2	...	2	7	...	7
Sweden								...	...
Switzerland	10	5	15	2	4	6	4	1	5
United Kingdom	54		54	102		102	83	..	83
Total	145	107	252	145	155	300	120	90	210

1. Data incomplete

A still more serious problem is the uncertainty which for several years now has been hanging over the proclaimed reorganization or the actual developments in higher technical education in some countries, obviously, such a situation greatly hinders FEANI's efforts to classify technical education establishments.

It is therefore difficult for FEANI to take specific action.

The booklet has been able to set out only general directives which must be supplemented as required by specific instructions adopted by the Register Committee. Thus, one of the problems currently being examined is that of the registration of candidates who are in special circumstances. e.g. foreign professionals, nationals who have acquired their qualifications in a foreign country, etc.

To conclude the discussion of the problems of registration, it may be of interest to know how many registrations were made in 1970, 1971 and 1972. In 1970, 252 professionals were registered, 145 of whom were in group A and 107 in group B In 1971, the corresponding figures were 300, 145 and 155 At the time of compiling this study, figures for 1972 were still incomplete but stood at 210, 120 and 90 respectively (see Table 1). In this connexion, it must be made clear that these numbers apply to only half the national members of FEANI, since the register has not yet been actually applied by the other half, furthermore, it should be pointed out that the Danish national member alone registered 149 professionals in 1970, 160 in 1971 and 93 in

1972.[1] Lastly, the over-all registration figures should be compared with the total number of professionals affiliated to the national members of FEANI. 680,550 on 1 January 1970, one reason for the low percentage of registrations is that the number of professionals who wish to leave their own countries is still very small.

The following remarks will be expanded in the conclusion to the present work, but it seems essential to introduce them at this stage.

It may be asserted that in the light of experience there is a very marked tendency to transfer educational establishments from group B to group A. This is a result of the gradual raising of the educational level in a given establishment. This is a *de facto* situation which does not change the qualification criteria, but which nevertheless leads to difficulties, as already mentioned, when certain national members attempt to put the register into application.

At all events, the present structure of the register, taken as a whole, is binary in type (groups A and B) and it seems that the trend is gradually turning towards a ternary system through the addition of a new group with an 'execution' function, which will perhaps give fresh impetus to the register in its attempts to achieve FEANI's objectives. Here it should again be mentioned that the British Council of Engineering Institutions, which is to all intents and purposes the British national member of FEANI, in 1971 brought together under its authority all chartered engineers (formerly called 'professional engineers'), technician engineers and technicians, and this was done under the auspices of a Royal Charter. At the same time, the Brussels Commission of the EEC, in drafting the proposal for Directive No. 2 concerning engineers, favoured the adoption of three categories of 'technicians' (a term replaced in this study by 'professional technologists' or 'professionals').

As FEANI has been influenced to move in this direction by one of its national members, and as it also knows the slant given to the problem by one of the international governmental organizations whose work it follows, it has no choice but to examine the possibility of changing the structure of its register. The question has been raised.

1 Moreover, the Danish national committee has announced that its engineers are able to find posts abroad more easily when they hold a certificate of enrolment in the FEANI register

3 Structure of the technological education system

3.1 The three categories

As already mentioned in the Chapter 1 not all the member countries of FEANI at present provide technological education in all three categories, C, L and E, since the structure of education in some cases has not yet been adapted to meet current needs. Consequently, we shall discuss the actual situation country by country taking the three categories as a basis for comparison.

The present situation is of course explained by the individual history of each of the member countries of FEANI, successive variations in the structure of the technological education system having occurred not only without international co ordination but often, too, without a reappraisal of the structure as a whole at the national level. New provisions were simply superimposed on the old ones.

In view of the independent and often haphazard development of national structures, it is not surprising that the steps taken fairly recently at the international level with a view to finding common denominators—for instance the EEC's proposed Directive No. 2 or, earlier, FEANI's *European Register of Higher Technical Professions*—are not always altogether appropriate to the real situation in this or that country, which is a heritage of the past.

Nor is it surprising that the countries where these international initiatives are almost perfectly appropriate—as, for example, the United Kingdom with its ERB national register—are precisely those where the structure of the technological education system has recently been reconsidered as a whole.

In many countries the problem is further complicated by the fact that in some cases one must distinguish not only between a variety of technological professions but also between the older and the more recent degrees conferred by the same institution, which, following changes in curricula, may, for example, provide a more scientific and less practical education than it did before, although this change of emphasis does not automatically entail any change in the actual degree. In such cases the pure and simple assimilation of an earlier qualification to a later one of higher value (or of older graduates from an institution to more recent ones) is obviously a simple and practical legal solution, but it does not affect the real problem, which is that of distinguishing between two graduates with different education.

A few concrete examples are given below to illustrate the kind of difficulties encountered.

In *France* the qualification *ingénieur diplômé* (certificated engineer) (Law of 10 July 1934), is legally conferred by 143 engineering schools. Their respective courses vary none the less in some, the emphasis being on conception (C), in others, on liaison (L)—and this is a well-known fact. Furthermore, graduates of the university institutes of technology (IUT) who hold the *baccalauréat* (examination giving access to university studies), that is, who have completed thirteen years of primary- and secondary-school studies followed by two years of technological studies at university, are products of the L emphasis, although they do not meet the L-1 or L.2 1 or L.2.2. or L-3 criteria to the letter.

In *Czechoslovakia*, there are only engineering schools (category C), and schools for technicians (category E). This binary pattern does not exist in sixteen other FEANI countries, which have a ternary pattern, even if the professionals of one of the three categories are trained abroad. Only in Italy is the situation similar to that in Czechoslovakia.

In one country out of the eighteen, *Luxembourg*, there is no national school for category C (conception). Professionals in this category are educated abroad. But the three categories exist in professional life, of course.

The case of the *Federal Republic of Germany* affords an illustration of the difficulties resulting from the evolution of ideas on education.

More detailed consideration is given to it in the monograph on that country. Only a few observations will be made here.

Up till now the *Technische Hochschulen* (technical universities) have been educating graduates in category C (conception). Formerly the *Ingenieurschulen* (schools of engineering) educated graduates of category L (liaison). This level of education was recently strengthened in the *Fachhochschulen* (advanced full-time vocational education schools), although it was not strictly standardized. Some students receive three years of post-secondary technological education, others four years. It is still not perfectly clear whether these graduates are all of category L or whether some of them do not rather exceed this standard and come nearer to standard C.

Nor have matters remained there, for a bill has been tabled with a view to combining the following types of education in *Gesamthochschulen*, or comprehensive technical universities. (a) education of the type given in *Technische Hochschulen*, the level being slightly lowered apparently, although it would still come within category C, (b) education of the type given in the *Fachhochschulen*, which would apparently be strengthened, although it is hard to say now whether it would tend towards category C or category L.

The existence of graduates of the former *Ingenieurschulen* adds a complication—due to the past (a normal complication, one might say)—to the almost total uncertainty as regards the rapidly changing legal structure of the technological professions in the Federal Republic of Germany This case is rather exceptional it represents the greatest complication at present in the establishment and application of criteria for classification. Among the eighteen FEANI countries, the only other exceptional cases are Czechoslovakia and Italy.

3.2 Relations with the authorities

Relations between the universities and higher technological institutions, on the one hand, and the authorities, on the other, also vary from one country to another.

In most countries, institutions of higher technological education (universities and colleges) are, in some measure, independent of the authorities, which does not mean that they are by any means totally independent, for the authorities, which in most cases finance them to some extent, necessarily control their budgetary expenditure. Then again, the same authorities, while leaving institutions for higher technological education free to organize their internal administration, to establish their curricula in detail, and of course their time-tables and their detailed supervision, nevertheless exercise some control over the general outline of these curricula (which usually have to be submitted to them for prior approval) and the general outline of their application (type of examinations, etc.).

The degree of autonomy—which does not mean independence—varies from one country to another.

In some countries, such as *Denmark* and *Czechoslovakia*, institutions for higher technological education are financed entirely by the State. However, whereas in Denmark this goes hand in hand with great academic freedom, in Czechoslovakia it is accompanied by strong centralization of the administration of education, of the aims of teaching and research and of curricula in the Czech and Slovak ministries of education. Details of the curricula are, however, left to the institutions themselves.

In *Greece*, where fees are minimal (education is almost free of charge), all institutions are subsidized and yet enjoy considerable autonomy.

In the *Netherlands* there is a mixed system. On the one hand there is State education (*openbaar onderwijs*) with schools and universities founded, administered and almost totally financed by the State or by municipalities and, on the other hand, there is private education (*bijzonder onderwijs*) with schools and universities founded, administered and managed by denominational or similar organizations. The latter, too, are financed largely by the State.

In *Finland* four of the six colleges that provide higher technological education are run either by local authorities or are private, but these too, are supervised by the National Board of Professional Education of the Ministry of Education.

In *France* private institutions are wholly independent unless they are recognized by the State in which case they are generally subsidized, and are then like State institutions, only partly independent. All diplomas are issued, or recognized, by the State except those of the private institutions, whose diplomas are recognized only in certain cases.

One aspect of the situation with regard to the secondary education preceding higher education in technology in *Sweden* is worth noting. In that country scientific and technical secondary education varies in length according to the options the pupil will take at the higher level. The course covers only two years for pupils who choose mechanical engineering,

production techniques, motor mechanics, building and civil engineering or electrical engineering. Those who select physics and chemistry follow a three-year course. There is even a four-year course for pupils who wish to study certain aspects of science and technology.

Another notable feature of the Swedish system is that admission to these various types of scientific and technical secondary education is governed by the relation of the number of candidates to the number of places available. The number of places is fixed annually in accordance with the general provisions laid down by Parliament. When the number of candidates is in excess of this fixed number of places, students are admitted to each type of higher education on the basis of the marks obtained at an entrance examination, which is not otherwise required, or at least not in the case of students who have completed three years of scientific and technical secondary education.

3.3 Scientific content of the initial education

3.3.1 Engineers in category C

In *Belgium*, after six years of primary education and six years of secondary education, the student takes a five-year course leading to the degree of candidate civil engineer. The first two years of this course are devoted to the acquisition of a general knowledge of mathematics, physics and chemistry. (A detailed syllabus will be found in the Appendix.)

The other three years of the course leading to the degree of civil engineer cover a number of common subjects and nine groups of subjects corresponding to nine special branches, which are as follows. mining, civil engineering, metallurgy, chemical engineering, electrical engineering, mechanical engineering, shipbuilding, architecture, textiles.

Further special branches are likely to be made available by the universities.

Whichever one of the nine branches is taken, the last three years of the course comprise lectures, practical work and laboratory work and conclude with the preparation of a thesis.

Summing up, in *Belgium* the common core of the first two years (*candidature*) devoted to general subjects is followed by three years of more technological studies, comprising both subjects common to all nine special branches and subjects peculiar to the special branch selected.

It is interesting to compare this rather rigid Continental pattern with the much more flexible British pattern.

In the *United Kingdom*, university courses are devoted chiefly to lectures on theory and to projects. Practical training is obtained in the main at a later stage in the course of one's career or else by means of sandwich courses alternating with university courses. The polytechnics, on the other hand, teach theory which is immediately applied. Consequently, practical training is given as part of the course.

Secondary education in the United Kingdom involves a choice of ordinary-level (O level) subjects (for which examinations are taken around the age

of 16) and advanced-level (A-level) subjects (for which examinations are taken around the age of 18–19).

Under these circumstances the British student can receive the scientific education required to become a chartered engineer in one of the following five ways, depending on the type of secondary course which he has taken:

1 Having completed a scientific secondary education comprising three O-level subjects and two A-level subjects or one O-level subject and three A-level subjects, he can continue his studies at a university for either (a) three years full time or (b) four years with integrated sandwich courses, university courses being alternated with practical experience in industry according to a pattern approved and supervised by the university.
2 Having completed a scientific secondary education comprising three O-level subjects and two A-level subjects, he can continue his studies in a polytechnic for four years with sandwich courses.
3 Having completed a scientific secondary education comprising four O-level subjects and one A-level subject, he can do three years of sandwich courses in a polytechnic or certain other colleges leading to the Higher National Diploma, followed by at least one year of full-time study for the second part of the examination of the Council of Engineering Institutions (CEI).
4 Having completed a technical secondary education comprising four O-level subjects and having followed this by two years of part-time study in one of various colleges leading to the Ordinary National Certificate, he can either (a) do two years' part-time study leading to the Higher National Certificate, followed by at least a year of full-time study for the second part of the CEI examination, or (b) study for the first part of the CEI examination and then do at least a year of full-time study for the second part of the CEI examination.
5 Having completed a technical secondary education comprising three O-level subjects, then three years of part-time study in one of various colleges leading to the City and Guilds Certificate, and having followed it by a year of part-time study leading to the City and Guilds Full Technological Certificate, he can study for the first part of the CEI examination and then do at least one year of full-time study for the second part of the CEI examination.

The case of *Belgium* can be quoted as an example to refer to for the scientific education of engineers in category C (conception) by reason of: (a) the entrance level, which is situated after six years of primary education and six years of secondary education, (b) the duration of the course, which is five years, comprising two years of basic education and three years of technical education (applied sciences), (c) the fact that the education, which is both scientific and technological, is at university level.

It should be noted that in certain European countries C-type education covers only four years. At first glance one might think that the education is less thorough. However, the view is sometimes taken that the essential

criterion is the university level of the basic education, since technical education proper can be supplemented later by professional experience. This would be one particular aspect of continuing education. The success of this scheme naturally depends on the student's having acquired in the course of his studies a taste and ability for self-education—a fundamental aspect, moreover, of his personality. In other countries the system is closer to the Belgian pattern. Such is the case, for example, in the Federal Republic of Germany and certain engineering schools in France.

It is emphasized that, in the Belgian example, the teaching of the applied sciences (three years) involves a considerable amount of laboratory work, detailed practical work and the preparation of a complete project at the end of the course (for instance, a project for a dam in the civil engineering branch or a project for an electric motor in the electrical engineering branch).

Similar projects are required at the end of the course in the *Technische Hochschulen* in the Federal Republic of Germany and certain engineering schools in France.

The main features of the British system are the several ways of entering the profession and the importance attached to practical training. It is not easy to compare this system with the Continental system on the basis of the texts. However, the length of the studies in general, the nature of the scientific education and also the results obtained in industry give the impression that, all in all, the two types of education are equivalent.

3.3.2 Engineers and senior technicians in category L

In *Finland* the education of professionals in this category is divided into seven sections. mechanical engineering, electrical engineering, civil engineering and the timber industry, chemical engineering, paper manufacture, production techniques, data processing.

The courses last four years, or three years if the student has passed the final secondary-school examination. For the first two years the basic courses cover elementary mathematics, mathematics, physics and chemistry, the two national languages (Finnish and Swedish) and one foreign language.

During the first two or three years the general vocational courses cover draughtsmanship, strength of materials, mechanical engineering, electrical engineering, technology of raw materials, etc.

Finally, the last two years are devoted to specialized vocational education. General education in production, economics, etc., is also given in the last year.

In *France* students educated at the *instituts universitaires de technologie* (IUT) obtain a *diplôme universitaire de technologie* (DUT) at the end of a two-year course in one of the following nine special branches. applied biology (agronomy, food industries, dietetics, biological and biochemical analysis, environmental hygiene), chemistry, chemical engineering, civil engineering (building and public works), electrical engineering (electrotechnology, electronics, automatic control), mechanical engineering (construction and manufacture), heat engineering (heat machines, heat generators, refrigeration machines, air-conditioning), physical measurements (physico

chemical and physical techniques and measurements), hygiene and safety (accident prevention and public safety, hygiene and safety in the working environment).

Also in France, holders of the *brevet de technicien supérieur* (BTS) are educated in some forty branches falling within one of the following six groups: civil engineering, metallurgy, mechanical engineering, electrical engineering, textile industries, chemical and physico-chemical industries, various vocational activities; applied arts.

In *Luxembourg*, technician engineers follow a three-year course at an institute of technological education. The scientific subjects (mathematics, physics, mechanics, electricity, statics) account for 72 per cent of the whole course, general educational subjects and practical work accounting for 18 per cent and 10 per cent respectively.

In the *Netherlands*, technician engineers in category L follow a four-year course at a *hogere technische school*, general subjects and science (mathematics, physics, chemistry, mechanics) representing 50 per cent, whereas the remainder is devoted to practical education.

It is interesting to compare the Continental education given in these four countries with the corresponding British education.

In the *United Kingdom*, technician engineers first receive a technical secondary education comprising three O-level subjects. They then take a three-year part-time course in one of various colleges leading to the City and Guilds Certificate, then a one-year part-time course leading to the City and Guilds Full Technological Certificate.

The case of *Finland* may be regarded as a good example for reference. (a) the level of admission is at the end of the secondary school course, although there is a certain flexibility, (b) the course covers three years following the secondary school course (although there is some flexibility here too); (c) the nature of the education is of the higher technological type with specialized courses for the different branches.

As has already been said, the prototype is not followed in detail in all countries. In *France*, for example, the *diplôme universitaire de technologie* (DUT) is conferred after a two-year course following the secondary-school course. However, the latter covers thirteen years and not twelve.

While different views may be held concerning such cases, it seems reasonable to consider that the graduates concerned do indeed belong to category L.

In the *Netherlands*, the course covers four years after the secondary-school course. However, the education is of the higher technological type with particular stress on the practical aspect.

Here too, the British system can only be roughly approximated to the Continental one, partly on the basis of the results obtained in industry.

3.3.3 Technicians in category E

In *Luxembourg*, the science subjects taught at an institute of technological education after a secondary school course of lower standard than that required for university entrance comprise: algebra, analytical geometry,

descriptive geometry, trigonometry, differential and integral calculus, physics, chemistry, mechanics.

However, these science subjects represent only 22 per cent of the course, 60 per cent of which consists of practical training, and the remaining 18 per cent of general subjects

Similarly, in the *Netherlands*, after an incomplete secondary-school course students follow a four-year course in an *uitgebreid technische school*, 50 per cent of the time being devoted to general subjects and science (mathematics, physics, chemistry, mechanics) and 50 per cent to practical training.

By contrast with these two examples of the Continental system, the education of a technician in the *United Kingdom* may be of one of the following three types: (a) a scientific secondary-school education comprising four O-level subjects followed by two years of sandwich courses at one of various colleges leading to the Ordinary National Diploma, (b) a technical secondary education comprising four O-level subjects followed by two years of part-time courses in one of the various colleges leading to the Ordinary National Certificate, (c) a technical secondary education comprising three O-level subjects followed by three years of part-time courses at one of the various colleges leading to the City and Guilds Certificate.

The case of the United Kingdom can be taken as an example for reference. With regard to the third possibility (c), we would make the following comment. if the reader refers back to Section 3.3.1 he will see that British secondary education with O-level subjects normally ends at the age of 16, which sets the entrance level for the technological course proper.

This technological course covers three years in a technical college, which sets the type and duration of the course. It is immediately apparent that these conditions exactly fit the initial definition of the criteria for E-1 and E-3.

Here again the existence of different possibilities in the British system will be noted.

3.4 The practical content of the initial education and training

3.4.1 Category C professional technologists[1]

In the *Federal Republic of Germany* six months of basic practical training (*Grundpraktikum*) is required for admission to a *Technische Hochschule* (Technical University). Students at a *Technische Hochschule* also have to do a period of practical training lasting six months (*Fachpraktikum*) in the course of their studies.

In the *Netherlands*, students at technical universities receive practical training in the course of their studies. The period of such training varies between sixteen and twenty-four weeks according to the case.

In *Switzerland*, students at the École Polytechnique Fédérale in Zurich are given practical training the length of which varies according to the

1 The term 'professional technologist' is used here in order to cover the full scope of 'chartered engineer', 'technician engineer' and technician in the British meaning of these terms In French, this corresponds to '*professionnel du domaine technique*'

section in which they are enrolled six months in the mechanical engineering and electrical engineering sections, twelve months in the agriculture and architecture sections, thirteen months in the forestry sciences section, eighteen months in the pharmacy section (which in this *école polytechnique* exists alongside a chemical engineering section, which is rather unusual).

In comparison with these three Continental countries, the *United Kingdom* requires future chartered engineers to. (a) acquire practical training in the engineering profession or through the performance of duties which will lead to acquiring this training, during a period of at least one year, (b) have at least two years subsequent experience in a responsible post in the engineering profession.

The requirements of the British system therefore go well beyond those of the Continental system in so far as prior practical training and subsequent professional experience are concerned.

The case of the Federal Republic of Germany can be taken as an example, generally speaking, requirements are similar to those obtaining in the United Kingdom in so far as prior practical training is concerned.

In some countries, such as *Belgium*, prior practical training periods are not required. The young graduate is in fact regarded as a trainee when he enters the profession. He is not regarded as a full engineer until he has gained a year or two of experience.

It will be noted that the need for two years' experience in the profession in order to comply with the C-1 requirements is consistent with the EEC draft directives.

3.4.2 Category L professional technologists

In *Finland* periods of practical training ranging from twelve to sixteen months, according to the case, are compulsory. They can be fitted in partly before the student enters the institution for higher technical education and partly during the summer vacation, which lasts four months.

In the *Netherlands*, students at a *hogere technische school* do compulsory training periods varying in length from sixteen to thirty-nine weeks according to the case.

By comparison with these two Continental countries, it is compulsory for technician engineers trained in the *United Kingdom* to have. (a) at least two years of prior practical training, (b) at least three years of professional experience later on.

Here again the British system is far more exacting than the Continental system as regards practical training and professional experience.

Finland may be taken as an example here, although the period of prior practical training required is shorter than that in the United Kingdom.

3.4.3 Category E professional technologists

In the *Federal Republic of Germany*, it is compulsory for technicians to complete two years of practical training after the *Mittlere Reife* (secondary-school certificate) before they go on to the technical course.

In the *United Kingdom*, it is compulsory for technicians to have. (a) at least two years of initial practical training, (b) at least one year of practical experience later on.

Here again we find that the British system requires more in the way of practical training and experience than does the Continental system.

The case of the United Kingdom can be taken as an example for reference, although the professional experience required before the certificate is conferred is not compulsory—for the time being at least—on the Continent, where the first years in the profession are regarded rather as an initial training period.

3.5 Conclusions regarding the scientific and practical content of initial education and training [1]

First, it is apparent that it is not easy to find a common denominator for the education received by the various categories of technologists in the different countries of Europe. The best approach is to lay down general criteria, as was done in turn by FEANI, the British CEI and the EEC Commission.

Second, some types of education are easily classified according to these criteria, others fall between two categories, e.g. the teaching of a particular subject may be over and above what is required for category E and at the same time not quite correspond to the minimum criteria for category L. This in no way detracts from the general concept of the three categories of technologists, which seems to correspond well with the general trend in the European countries.

Finally, a difference in approach is to be noted, however, as between the British type of education and training on the one hand, and the Continental type on the other. This calls for special comment. (a) the relatively great importance attached not only to practical training during the course but also to practical experience after its completion is a feature of the British system. (The EEC's stipulations in Draft Directive No. 2 concerning two years professional practice after completion of studies in order to qualify for one or the other of the categories of technologists will certainly be noted with interest.), (b) access to the profession seems to be far more flexible in the United Kingdom, for example the five different ways of becoming a chartered engineer (category C) and the three different ways of becoming a technician (category E), (c) these differences in approach do not, however, make for very different results, to take one instance, British industry and German industry can both be proud of their achievements. This is an *a posteriori* finding which is not without value and meaning.

3.6 Post-graduate or continuing education and training

For post graduate education, taken in the most general sense, we shall for preference use the term 'continuing education' (and not 'continuous

1. See the preceding two sections.

education') in order to emphasize the fact that, according to modern conceptions of education, an individual's education is continued throughout his working life so that he can adjust to the constant development of science and technology, a development which is accelerating all the time Although it is continuing, post-graduate education is rarely continuous, for an individual anxious to brush up his knowledge in his special branch, to change to another branch or to extend the knowledge he has already gained, generally does so in a sporadic and discontinuous fashion.

When 'continuing education' is referred to, there is a tendency to confuse very different purposes At least three distinct purposes of continuing education and training should be distinguished:

1 Updating one's knowledge in a given branch, in order to keep pace with the changing techniques of that branch We shall call this particular purpose of continuing education 'updating' which has a positive meaning, implying the prevention of obsolescence of knowledge. We prefer this term to the more commonly used 'retraining' which in this connexion gives a somewhat negative impression, implying the curative treatment of obsolescence which has already begun.

2. Gaining new knowledge in a different branch (for example when a person wishes to change to another branch with better prospects for a career) We shall call this particular purpose of continuing education 'reconversion'.

3 Adding to the knowledge already acquired in one's own branch (this arises when a graduate engineer wishes, for example, to prepare a doctoral thesis which will raise the level of his knowledge in the same branch), or gaining new knowledge of more general subjects (such as management or data processing, for example). We shall term this particular purpose of continuing education 'further education'.

In connexion with these three fundamental purposes—updating, reconversion and further education—mention must be made of the incentives, the aims, the means and the results of these particular types of continuing education:

Advancement—that is, obtaining qualifications in order to pass from category E to category L or from category L to category C. This is at the same time the incentive for, the purpose and the result of going in for further education.

Education grants—that is, financial resources made available to individuals through a special fund or by employers to enable them to continue their studies. This means, which makes it possible to combine with good effect full time study and part-time study, can also be used for further-education with the specific aim of obtaining advancement.

Adaptation of theoretical knowledge to industrial practice. This particular aim can be attained by means of educational courses.

Before distinguishing between the three distinct fundamental aims—updating knowledge, reconversion, further education—let us see how continuing education is made possible for persons employed in industry in certain countries.

In *France*, the Law of 16 July 1971 relating to vocational education makes the following provision (a) employers must devote 0 8 per cent of the payroll (2 per cent as from 1976) to staff training, (b) a wage-earner may ask for study leave under certain conditions (for example to attend an educational institution approved by the State, for a period not exceeding 100 hours annually, which do not count as part of his paid annual-leave entitlement).

This law also provides for the specific aims of advancement and adaptation and the specific means of education grants. The Conservatoire National des Arts et Métiers (CNAM) and its affiliated centres in many provincial towns organize evening courses which are attended by tens of thousands of persons working in industry. The purpose of these evening courses is to dispense the widest possible range of scientific and technical knowledge. The corresponding examinations are held and certificates are awarded. A very small proportion of those enrolled manage, after years of lectures and laboratory work, many partial examinations, a general examination and the defence of a thesis, to obtain the *diplôme d'ingénieur CNAM*. This degree course is focused mainly on research (and consequently conception). Other courses are organized by the Ministry of Labour and employers' associations.

In *Luxembourg*, seminars are organized periodically by the Office Luxembourgeois pour l'Accroissement de la Productivité for persons in positions of responsibility, while the Université Internationale des Sciences Comparées holds seminars on economic subjects.

In *Denmark*, in 1971 the two Danish associations of engineers gave more than 300 courses totalling 200,000 student hours. These courses were attended by from 4,000 to 5,000 engineers.

In the *Netherlands*, the institutions for professional education have 72,000 full-time students and 51,600 part-time students.

In the *United Kingdom*, the 'day-release' system (granting of one working day) or the 'block-release' system (granting of a period exceeding one working day) give persons employed in industry time for continuing education More than one-third of the chartered engineers licensed annually are the product of a combination of formal education and professional experience.

In *Czechoslovakia*, persons engaged in continuing education are given a subsistence allowance, covering a certain number of days or weeks in which to prepare for their examinations.

3.6.1 Updating of knowledge

In *France*, courses for 'brushing up or improving knowledge (updating of knowledge), in some cases with the financial participation of the State, are defined in Article 10 of the Law of 16 July 1971 relating to vocational education Some large concerns such as the Régie Nationale des Usines Renault or Electricité de France organize their own courses for this purpose.

In *Luxembourg*, industrial firms give their engineers an opportunity to improve their knowledge in institutes in foreign countries, such as the Fondation Industrie-Université in Belgium, the Cégos in France, etc. Some companies also bear the expense of having their future foremen or technicians trained in specialized institutions abroad, such as the École de Maîtrise et

d Ouvriers Métallurgistes (EMOM) at Longwy, France Fairly large industrial concerns organize periodical training courses for their staff and bring in specialized instructors from neighbouring countries

In the *Netherlands,* international firms, such as Philips and Unilever, organize refresher courses for their staff.

3.6.2 Reconversion to another branch

In *Belgium,* the polyvalent education of the holders of the 'civil engineer' degree enables them to change very easily from one branch to another, from mining to civil engineering for example.

A civil engineer, after one year of additional study, can obtain a university degree in one of the following twelve branches. geology, operational research, physics, applied mathematics, hydraulics and hydrography, radio-electricity industrial management, applied nuclear sciences, petrochemistry, geotechnics, automatic control, town planning.

This particular example illustrates the way in which the evolution in techniques and the advent of new techniques (applied nuclear sciences, automatic control, etc.) have affected the education given in Belgium to engineers in category C (conception).

This problem has been solved in Belgium by means of an 'additional step'. Generally, an engineering geologist is a mining engineer who has taken a special course in geology. Similarly, an engineer in geotechnics is generally a graduate in civil engineering who has taken a special course in geotechnics.

The studies leading to this higher level start either immediately after graduation or, more often, in the course of the engineer's career.

In this connexion, we might mention, to supplement the information regarding the influence of the new techniques, that the basic theoretical education (mathematics, physics, chemistry) is also constantly evolving even if the names of the subjects remain unchanged. For example, the term physics now includes rudiments of nuclear physics, which makes it easier for the graduate to take up later the additional studies required for the degree of engineer in applied nuclear sciences. The same is obviously true of the term mathematics. A proper training in automatic control in just one year of additional study is inconceivable unless the graduate has already acquired a firm foundation in the Laplace transform and its extension—the Z transform—to non-linear systems and in the as yet relatively little taught Boolean algebra and the possibilities for its application.

In *Finland,* if an engineer already holding a diploma from a college of technology (category L) wishes to change his special branch, he must take courses in the new branch and then obtain from twelve to sixteen months experience on the job.

In *France,* training periods for 'reconversion and adaptation' (reconversion to a new branch) with, in some cases, financial assistance from the State, are defined in Article 10 of the Law of 16 July 1971 on vocational education.

In *Norway*, the only means of retraining open to a graduate of the Norwegian Institute of Technology (category C) is to study for a Ph.D. degree in the new branch.

In the *United Kingdom*, an engineer may belong to several professional associations corresponding to different branches, all affiliated to the Council of Engineering Institutions (CEI). He may specialize in a new branch through practical experience and/or through continuing education.

In *Switzerland*, if an engineer wishes to change to another branch, he must take another examination for the Swiss national register.

3.6.3 Further education

In *Denmark*, as in many other countries, courses are available (as at the Danmarks Tekniske Højskole) leading to a degree or doctorate in technology. Post-graduate study can also be undertaken at the School of Economics and in the universities.

In *France*, courses for obtaining advancement in one's career and pre-training courses for young people (further education), in some cases with financial assistance from the State, are defined in Article 10 of the Law of 16 July 1971 on vocational education. As we have already said, this type of further education generally results in advancement. Education grants may be awarded for attendance at these courses. The adaptation of knowledge by means of short training courses is another possibility offered by further education.

3.7 Trends in the structure of the technological education system

3.7.1 The possibility of grouping together courses for professional technologists in category C and category L

Most of the courses for engineers in category C and engineers and senior technicians in category L differ basically from those for technicians in category E. The former are at post-secondary level, whereas the latter run more or less concurrently with the end of the secondary course.

In most of the FEANI countries, one can assimilate: (a) the education of engineers in category C to long post-secondary education, (b) the education of engineers and senior technicians in category L to short post-secondary education.

In some cases the short post secondary course may be followed by continuing education up to a standard equivalent in practice to that of the long post-secondary course.

There is a difficulty here, however, inasmuch as the continuing education then consists mainly of basic scientific subjects (mathematics, physics, chemistry) and additional applied science subjects. It involves changing from the liaison category to the conception category, which demands a considerable effort and a great deal of time.

Such a change should by no means be the rule, but rather an exception, for the two categories are of a very different nature.

As both courses, the long and the short, are post-secondary courses, it seems likely (judging by one case, at least) that there will be a tendency to bring them together in one and the same institution This tendency is also due to the rise in the level of the qualifications of category L engineers in some countries and their consequent desire to be assimilated to category C engineers.

An illustration of the above tendency is provided by the Federal Republic of Germany, where the *Technische Hochschulen* (the present technical universities for category C) and the *Fachhochschulen* (the new engineering schools rep'acing the old *Ingenieurschulen* of category L), corresponding respectively to the long course and the short course, are likely to be brought together in future in *Gesamthochschulen* (new comprehensive technical universities).

In order to grasp the mechanism of the very specific case of the example of the Federal Republic of Germany, let us take a quick look at the respective situations of the present *Technische Hochschulen* (category C), the old *Ingenieurschulen* (category L), and the *Fachhochschulen* which now replace the later (a category not yet satisfactory defined, but probably closer to category C than at present).

Students are admitted to the *Technische Hochschulen* (the present technical universities for category C) after thirteen years of primary and secondary education, comprising four years of primary education in a *Volksschule* and nine years of secondary education in a *Gymnasium*, leading to the *Abitur* (the secondary-school certificate giving access to university studies). After a basic practical training period of six months (*Grundpraktikum*), students admitted to a *Technische Hochschule* take a course lasting from five to six years, including another six-month period of practical vocational training (*Fachpraktikum*). They receive a degree after presenting a final thesis.

Students were admitted to the old *Ingenieurschulen* (engineering schools for category L) after ten years of primary and secondary education, comprising four years of primary education in a *Volksschule* and six years of secondary education in a *Realschule* leading to the *Mittlere Reife* (certificate awarded at the end of an incomplete secondary course with a practical bias). Students were admitted to an *Ingenieurschule* after two years' practical experience and took a three-year course.

Students are admitted to the new *Fachhochschulen*, which replace the former *Ingenieurschulen*, after twelve years of primary and secondary education, comprising four years of primary education in a *Volksschule* and six years of secondary education in a *Realschule* leading to the *Mittlere Reife*, and a two year technical course at the secondary level in a *Fachoberschule* (higher vocational school) leading to the *Fachoberschulreife* (diploma awarded at the end of the technical secondary course). Students admitted to a *Fachhochschule* complete a three-year course followed by a year of practical training

As for the future. the possibility of bringing together the *Technische Hochschulen* and the *Fachhochschulen* within *Gesamthochschulen* (comprehensive technical university) seems to be contemplated on the following common basis admission on the same conditions (twelve years of primary and secondary education), regardless of the type of upper secondary course, a common core of basic subjects for a period not exceeding two years,

diversified courses according to the branch, a period of practical training of at least three months at the start of the technical studies, another period of specialized practical training during the course, lasting from three to twelve months, depending upon the branch selected.

It is not yet quite clear whether separate degrees would be conferred for the various branches or whether there would be a single degree.

The above example illustrates a possible trend towards grouping together engineers in categories C and L. It remains to be seen whether the experiment being carried out at present in the Federal Republic of Germany will be followed by other European countries and also what shape it will finally take in the Federal Republic of Germany itself.

3.7.2 Trend towards adapting the system of initial technological education to the conditions of subsequent continuing education

The best way to illustrate this trend will be to give a selection of quotations from the report submitted on 20 October 1972 to the Consultative Assembly of the Council of Europe by Rector Capelle, Chairman of the assembly's Committee on Culture and Education. The report was unanimously adopted by the assembly.

Among other important factors in the present university crisis are the need for the graduate to realize that his studies are incomplete', that is, the need to create an inclination for self-education. This no doubt requires less knowledge and more know-how.

Education and initial training methods still have to be revised in order to achieve a *calculated incompleteness* so as to maintain curiosity and encourage self-culture. It is clear that there is still a tendency to extend further studies and for the final consecration to be seen as investigating static knowledge rather than providing a guarantee of the ability to select, put into practice, and decide.

Continuing education .. must be regarded as the natural extension of initial education so that the professional diploma in which it culminates is considered more as an initial springboard than as a finishing post.

By stressing knowledge above all else, university studies in accordance with tradition have helped to bring about the life diploma ensuring total security and thus providing little incentive ever to challenge what has been learned.

By laying greater stress on ability to process knowledge (adaptability as it is sometimes termed) or on the capacity to learn to learn', the stagnation of the life diploma gives way to the stimulation of 'lifelong learning'.

The previous life diploma' should become a temporary certificate of proficiency requiring regular confirmation in forms to be determined according to the situation.

Viewed from this angle, the diploma becomes a strictly personal matter and the information it provides is confidential in the same way as that of a medical diagnosis. As it refers to a particular point in time, it will require regular confirmation in the same way as flying certificates awarded to airline pilots.

We do not know to what extent these ideas are directly applicable in real life, particularly to the world of European engineering, but we feel sure that, at present, some of them would raise difficulties in practice.

However, we have quoted large extracts from this report to illustrate a trend which seems entirely justified in our view and which meets the need not only for supplementing the initial education by continuing education (which seems obvious), but also, and above all, for organizing the former in preparation for the latter.

4 Legal provisions

In this chapter we shall examine the conditions governing the use of professional qualifications and the practice of the engineering profession in the various FEANI countries.

It should be borne in mind that for the most part our information concerns the qualification of engineer.

Use of the qualification of engineer and practice of the engineering profession may be governed by one of the following four conditions. (a) compulsory membership of a corporate body in order to practise the profession, (b) voluntary registration in a national register in order to be able to use the qualification of engineer, but freedom to practise the profession, (c) neither compulsory membership nor voluntary registration, but legal protection provided for the use of the qualification of engineer, the profession being practised freely, (d) freedom to use the qualification of engineer and freedom to practise the profession.

The legal provisions relevant to each of these four conditions in the various countries will now be studied in turn.

4.1 Compulsory membership of a corporate body in order to practise the profession

In *Greece*, an engineer must be a member of the Technical Chamber of Greece (founded in 1923), otherwise he has no right to call himself an engineer or to practise his profession. This membership is acquired either (a) by taking all the examinations of a Greek technological university, or (b) after verification of training received abroad and a general professional examination.

In *Italy*, engineers must be of Italian nationality and must be recognized by the Consiglio Nazionale degli Ingegneri. The membership requirement for the latter is possession of the Italian diploma of *dottore in ingegneria* (the qualification of *ingegnere* is granted only afterwards by the Consiglio Nazionale degli Ingegneri which operates under the authority of the Ministry of Justice). Holders of foreign diplomas may be granted provisional permission to practise the engineering profession in Italy.

In *Portugal*, engineers are obliged to belong to the Ordem dos Engheneiros (National Order of Engineers).

In *Spain*, all engineers (except civil servants) must join engineering colleges attached to the appropriate technical ministries (public works, agriculture, industry, etc.).

4.2 Voluntary registration in a national register in order to use the qualification of engineer, but freedom to practise the profession

In *Ireland*, the plain qualification of engineer is not directly protected by the law, but in practice it does not have much meaning. Most engineers graduate from the universities, although some of them hold the qualification of engineer through having passed the Institution of Engineers of Ireland (IEI) examination.

This body confers the qualification of chartered engineer, which is protected by law, the conditions for obtaining it are as follows. minimum age 25, titular membership of the IEI, registration in the register of the IEI, through having obtained the qualification of chartered engineer from another recognized body which is itself a member of the IEI.

In *Switzerland*, the Swiss register, introduced in 1951, governs the use of professional qualifications. The institution, which is based on a convention between professional associations, was transformed in 1966 into the Foundation of Swiss Registers REG, whose task is to keep registers of three professional categories—engineers and architects, technician engineers and technician architects, technicians.

In the *United Kingdom*, chartered engineers, technician engineers and technicians gain the right to their respective qualifications by registering voluntarily with the Engineers' Registration Board (ERB) which is administered by the Council of Engineering Institutions (CEI). It shoud be noted that the Royal Charter—restricted initially to the category of chartered engineers—was recently extended to include technician engineers and technicians.

For this reason, and despite the fact that registration with the ERB is voluntary, this register has indisputable legal validity. Entry in the ERB register is in fact governed by the conditions laid down in the Royal Charter granted to the CEI. Thus, although there is freedom to practise the profession in the United Kingdom, it is likely to become more and more difficult for engineers, higher technicians, and technicians to practise if they are not entered in the British national register of the ERB.

4.3 Neither compulsory membership nor voluntary registration, but legal protection provided for the qualification of engineer, with freedom to practise the profession

In *Austria*, the Federal Law of 7 July 1948 governs the use of the qualification of engineer (category L (liaison)) and the Federal Law of 10 July 1969 governs the use of the academic qualification of *Diplomingenieur* (graduate engineer).

In *Belgium*, use of the qualifications of civil engineer and technician engineer is governed by the Law of 11 September 1933 on the protection of

qualifications acquired through higher education. The advisability of creating an Order of Engineers is at present under consideration.

The Royal Decree of 1 July 1957 protects the qualification acquired through secondary technical education (technician).

The recently created qualifications awarded at the end of the short course in higher technical education (senior technician, technical graduate, technical conductor, engineer's assistant) are not protected by law.

In *Czechoslovakia*, the title of engineer may be used only by former students of the technical and agricultural universities who have completed their studies in one of the sixteen Czech or Slovak technical universities and have been awarded the corresponding diploma.

In *Denmark*, the only protected qualifications are those of civil engineer (Danmarks Tekniske Højskole), academic engineer (Danmarks Ingeniørakademi) and *teknikum* engineer (category L) which may be used only by holders of diplomas awarded by the corresponding schools. This, however, does not amount to a legal restriction on the practice of the engineering profession.

In the *Federal Republic of Germany*, each of the eleven *Lander* has brought out a law protecting the right to use the qualification of engineer. The latter is confined to diploma-holders from the *Technische Hochschulen* (technical universities), from the *Fachhochschulen* (specialized vocational colleges, which have replaced and raised the level of the former *Ingenieurschulen*) and from the former *Ingenieurschulen* (schools of engineering), and to self-educated persons who used the qualification of engineer before the law came into force. For the past two years, use of the qualification has been the exclusive right of diploma-holders from the *Technische Hochschulen* and the *Fachhochschulen*.

In *Luxembourg*, the Law of 17 June 1963 protects the qualification of technician engineer (no category C engineers are trained in the Grand Duchy).

4.4 Free use of the qualification of engineer and freedom to practise the profession

In *Finland*, there are no regulations governing the use of the qualification or the practice of the profession.

In *France*, the Law of 10 July 1934 grants the qualification of *ingénieur diplômé* (graduate engineer) to engineers graduating from State-recognized schools, at the proposal of the Commission of Engineering Qualifications. However, the qualification of engineer is not protected by law. For the self-educated, it often corresponds to a post held in a firm.

In the *Netherlands*, the engineering profession is not governed by any regulations The only protection is that afforded to the university-level qualification of graduate engineer conferred by a technical university (*technische hogeschool*), which entitles the holders to place the abbreviation 'Ir.' before his name.

New graduates from the *hogere technische schoolen* (category L) will be entitled to use the abbreviation 'Ing.' after their name.

In *Norway*, the title given to engineers of category L, who graduate from the *ingeniørskoler* (formerly *teknisk skoler*) will henceforth be *ingeniør*. It is not protected by law. The only protected qualification is that of *sivilingeniør*, which has been protected since 1949 and is confined to diploma-holders of the Norwegian Institute of Technology (category C) and to Norwegian nationals who hold diplomas from foreign schools or universities recognized by the public authorities.

In *Sweden*, the qualification of engineer is not protected by law, the only persons who may be prosecuted under the law are those who use an established qualification which is not theirs by right.

5 The role of industry

5.1 Industrial requirements

As a rule, the requirements of industry are made known to establishments for higher technical education through the following four channels. (a). directly, through industrial representatives on the boards of these establishments, (b) less directly, through the presence on these boards of representatives from the Fellows' Associations of the establishments concerned, whose members work in industry, (c) indirectly, by virtue of the fact that certain teachers have worked in industry in the past or continue to do so as consulting engineers, concurrently with their academic activity, (d) by research contracts granted to the educational establishments.

In *Austria*, industry examines changes in the curriculum before these become effective and sends details of its requirements to the heads of the establishments concerned.

In *Belgium*, industry's requirements are conveyed to the university through an organization called the Fondation Industrie-Université.

In *Czechoslovakia*, industry's requirements are outlined by the appropriate technical ministries and passed on to the Czech and Slovak ministries of education.

In *Denmark*, industry's requirements are conveyed to the Danmarks Ingeniørakademi by an advisory committee, ten members of which represent industry, this committee is competent to alter the curriculum and the examination programmes.

In *Finland*, industry is represented both centrally and locally. as regards *centralized representation*, industry is represented on the Council of Higher Technical and Commercial Education, an advisory body to the Ministry of Education. It is also represented on the Vocational Education Council, an advisory body to the National Office of Vocational Education which is responsible for technical colleges in category L, falling under the control of the Technical Education Section of this office. As regards *local representation*, industry has representatives on the university councils. Its local representatives, who are chosen by the National Office of Vocational Education, also sit on the advisory boards of the State technical colleges (category L).

In *France*, representatives from the engineering world attend meetings of the Commission on Engineering Qualifications, one of these shares the joint chairmanship of this commission with a civil servant (often the head of an engineering school). In addition, industry's requirements are communicated

directly to the heads of the establishments, and in important cases to the appropriate ministerial authorities.

Furthermore, as regards the IUT (university institutes of technology), management and unions are represented at the national advisory commissions of the IUTs and on the board of directors of each IUT.

In the *Federal Republic of Germany*, the Federal Commission of Engineering Education, which is in contact with industry, communicates directly with the ministers of culture of the *Lander* and also with the Federal Conference of the latter.

In the *Netherlands*, almost half the teachers in technical education are 'part-time' teachers, who also hold posts in industry.

In *Spain*, each university has its *patronato* which is in charge of the university's public relations. In the special case of the technical universities, both industry and professional colleges have representatives in the *patronatos*.

5.2 Collaboration of industry

In Section 3.6, 'Post-graduate or Continuing Education and Training', we mentioned the facilities granted by industry, for example in Czechoslovakia, Denmark, France, Luxembourg, the Netherlands, and the United Kingdom, to persons undergoing continuing education whilst pursuing their work in industry. Industry's collaboration also takes the form of organizing practical training periods.

In *Austria*, industry organizes training periods during the holidays. In order to acquire the qualification of *Ingenieur* (category L), students from higher technical education establishments must have acquired four years' practical experience in their chosen branch.

In *Belgium*, industry participates in the education of engineers, (a) by means of practical training periods during the vacations, (b) during employment, by granting its engineers leave of absence and/or funds for continuing education.

In *Denmark*, practical training periods in industry lasting from six months to one year, are organized for students of the Danmarks Tekniske Højskole and the Danmarks Ingeniørakademi.

In *Finland*, the graduate engineer or architect (category C) should have had from six to nine months' practical experience in industry and the engineer (category L) from twelve to sixteen months. For the time being, this is an optional requirement, but it counts for extra marks in the examination. In addition, terminal study work is often carried out in industry, or else the subjects for such work are proposed by industry.

In the *Federal Republic of Germany*, two semester practical training periods in industry are a requirement of the *Fachhochschulen* in some *Lander*.

In *Spain*, one of the functions of the new university *patronatos* is to establish industry's influence in the education of engineers.

In *Switzerland*, industry plays an active part in self education, continuing education and the organization of practical training periods.

In the *United Kingdom*, there are several industrial training establishments, one of which is the Engineering Industrial Training Board. The CEI maintains contact between its own private vocational institutions and these vocational training establishments, each of which is specialized in one or more technological fields Such relations are supplemented by individual agreements between these industrial training establishments and schools on the one hand, and industrial firms on the other. For example, a technical college will contact industrial firms in its area in order to find out which of these are prepared to accept students for practical training periods. This is very largely a matter of supply and demand.

6 Relationships between categories C, L and E

6.1 The complementary nature of categories C, L and E

We have already stressed in Section 1.2, 'Conventional Definitions Adopted', that industry naturally has as much need of execution technicians (category E) as of conception engineers (category C) and liaison engineers or senior technicians (category L), without whom collaboration between the two preceding categories would undoubtedly give rise to many difficulties.

Opinions vary as to the desirable numerical ratio between the different categories. but it is clear that several engineers or senior technicians in category L are required for one engineer in category C.

Unfortunately, the real state of affairs seems to be very different. whereas there is usually an adequate number of conception engineers, there is generally a relatively widespread shortage of liaison engineers or senior technicians.

The main reason for this state of affairs is probably to be found in the prestige enjoyed, in the opinion of young people and their families, by long post-secondary as opposed to short post-secondary education, whereas in fact the latter offers future graduates relatively more openings than the former.

The harm thus caused to industry cannot be denied. It is as if the industrial 'army' possessed enough high-ranking officers and non-commissioned officers, but suffered from a shortage of junior officers, yet, as we all know, the quality of an industry, as of an army, depends largely on the quality of its supervisory and intermediate-level staff (and, of course, on their numbers).

The harm caused to the graduates themselves is also obvious, since large numbers of conception engineers are forced by the scarcity of liaison engineers or senior technicians in category L to do the work of the latter as well, the result is an inevitable sense of frustration on their part, since they feel that their particular abilities are not being fully used. The scarcity of liaison staff is sometimes attributable to use being made of category E execution technicians in their place, which is liable to impair the quality of the complementary relationship between the three categories.

This lack of middle level personnel in industry is not due solely to the fact that future graduates, and particularly their families, are looking for the prestige and higher social standing afforded by long post-secondary education It is also due to the continuous rise in the level of short post-secondary education, which tends to make it less worth while since less and less additional effort leads to a qualification which still remains above that ensured

by short post-secondary education. This 'levelling upwards' is one of the important factors in the shortage of category L engineers and senior technicians.

6.2 Social advancement

We are concerned here with methods of moving on from a qualification acquired in category L to a fresh qualification in category C, or from category E to category L. This 'upward movement' from the concrete to the abstract is not easy, since it requires the acquisition of supplementary theoretical knowledge after having first acquired a more practical grounding. It would be easier to move in the opposite direction. hence appropriate guidance is desirable from the beginning.

Yet such methods are essential to enable the most deserving to gain advancement, while social justice obviously requires this.

In *Belgium, ingénieurs techniciens* (category L) who have already completed three years' post secondary studies may qualify as *ingénieur civil* (category C) after an additional three-year course. Since this qualification is normally obtained only after five years' post-secondary education, they are thus required to study for a year more than if they had moved on directly to long post secondary education. It is thus not surprising that only 1 per cent of them avail themselves of this opportunity. This state of affairs is due to the difficulties pointed out above of passing from the concrete to the abstract.

In *Czechoslovakia*, students holding a diploma of specialized secondary education (technicians) may continue their studies in higher technical institutes for engineers.

In *Luxembourg*, technicians (category E) can take an examination for admission to schools for *ingénieurs-techniciens* (category L).

In the *Netherlands*, graduates of higher technical schools (category L) are admitted freely to technical universities for category C engineers, where they take the full course from the beginning.

The new law now being drawn up provides for the selection of students for both higher technical schools (category L) and technical universities (category C) by means of examinations held at the end of a one or two years' common core of pre-university studies.

In *Norway*, graduates of higher technical schools (category L) are admitted to the second year of the Norwegian Institute of Technology, which educates category C engineers, on condition that they take a course in mathematics in the summer preceding their admission. At present 30 per cent of the students at the institute have gained admission in this way.

In *Spain*, industrial technician engineers (category L) can go on, after supplementary education, to the second, two year course for 'senior engineers' (category C). Conversely, the first, three year course for 'senior engineers', when combined with a certain amount of self education, leads to the diploma of industrial technician engineer, which is obviously easier than movement in the opposite direction.

In *Switzerland*, technician engineers from higher technical schools (category L) may be admitted to polytechnics (which educate category C engineers) after taking an examination in general education.

In the *United Kingdom*, as already noted in section 3.3 1, 3.3.2, and 3.3.3, one of the main features of the system in force is its great flexibility.

It should be noted that these channels for social advancement are not yet highly developed.

6 3 Multiple channels of access to post-secondary education

In *France*, there are very many channels for admission to one of the 143 French schools educating graduate engineers:

For students in science faculties (without a competitive entrance examination) *either* for holders of the *diplôme universitaire d'études scientifiques* (DUES) at the first/second-year level, or first-year certificate (forty-nine schools), *or* on production of the DUES (fifty-three schools), *or* by special competitive examination reserved for holders of the DUES (twenty-three schools), *or* with a *licence* from a university or two *certificats de maîtrise* (seventeen schools), *or* with a *maîtrise universitaire* (seventy-five schools).

For post secondary pré-university students (*those in* classes préparatoires) (with a competitive entrance examination). either at the level of *mathématiques supérieures*, i.e. one year after the *baccalauréat* (fifteen schools only), *or* for those who have completed the *mathématiques spéciales*, i.e. two years after the *baccalauréat*, either *mathématiques spéciales A'* (fifty-eight schools), *mathématiques spéciales A'* (seventeen schools), *mathématiques spéciales B* (forty-eight schools), or *mathématiques spéciales C* (sixteen schools), *or* by a special competitive examination open to pupils from technical schools (thirty schools).

For students from technical schools (without a competitive entrance examination). *either* for holders of the *brevet de technicien supérieur* (BTS) (nineteen schools), *or* on completion of the preparatory curriculum for the École Nationale des Arts et Métiers, *or* with a *diplôme d'études supérieures techniques* (DEST) under the social advancement programme (in particular, for those who have studied at the Conservatoire National des Arts et Métiers (CNAM) but have not gone far enough to obtain the CNAM engineer's diploma, especially those who have not taken the general examination or submitted the final thesis for this diploma).

6.4 'Bridges'

Various means are provided which enable a student to switch during his studies from the course he has originally chosen to another which he believes, in the light of his initial performance, to be better suited to his ability. Such 'bridges' may enable a student to change from a more practical type of education to a more theoretical type (for example from a short to a long post-

secondary course), should the student find that his performance in theoretical fields is better than he originally hoped, and if he has a liking for them. Of course, a change in the opposite direction may also be made if he realizes that he has taken a theoretical course which is beyond his ability.

We have already stated in Section 3.7.1, with regard to the first of these alternatives, that short post-secondary education may be followed in some cases by continuing education to achieve an equivalence in practice with long post-secondary education chosen from the outset, but that this should in no way be the rule, but rather the exception, since the two careers are quite different from one another.

This remains entirely true for a possible change from category E to category L. In other words, 'bridges' should not become normal educational channels, but remain stand-by ones enabling individual students to switch from one type of course to another, be it practical to theoretical or vice versa.

In *Belgium*, Article 9 of the Law of 7 July 1970 makes provision for 'bridges' from one type of higher education to another, but the Law still awaits an enforcement decree.

6.5 Trends in relationships between categories C, L and E

As already stated in Section 6.1, a trend is emerging in a number of countries towards raising the level of schools training professional technologists in category L. It is to be foreseen that this trend will become general.

It is hoped that, as a result of this increase in level, this type of education will become more attractive to students and their families—without, however, encouraging them to turn towards long post-secondary studies, should the difference in level between these two types of education be slight, it may thus be possible to make up for the shortage of category L personnel which hampers industry in many industrial countries today.

Associations of former students of short post-secondary education can do a great deal to reinforce this trend. In the first place, they can refrain from demanding too high a level of education from schools training liaison engineers, since such a demand, while understandable from the human point of view, runs counter to efficiency in practice. It would be regrettable to create fresh confusion between conception and liaison engineers, thus producing a gap precisely where a shortage is already felt which is detrimental to the interests of the engineering profession as a whole. Raising schools for category L engineers to too high a level would lead to a situation worse than the present, which is due, in some countries, to their being at too low a level. Here again, therefore—and more than ever—great moderation seems to be required.

Associations of former students of short post-secondary education can render another great service to their members, both present and future. that of explaining the reason for the existence of their profession, which is as important for society as that of category C engineers.

Lastly, the widespread adoption of continuing education will make it possible to provide more numerous and widespread channels for social

advancement between the various categories of professional technologists, by giving the opportunity to those who want it to climb the successive rungs of knowledge and know-how, while continuing to earn their living. The examples of what has already been achieved on these lines (see Section 6.2) and the flexibility of the British system are convincing proof of this.

7 Bilateral and multilateral agreements on the education of engineers

Austria and the *Federal Republic of Germany* have concluded an agreement for the mutual recognition of engineering qualifications, which is to be extended to other German-speaking countries.

In *Belgium*, equivalences have been established by law between academic degrees awarded in Belgium and territories formerly under Belgian sovereignty or entrusted to Belgian administration, they are now being revised. Provisions exist for equivalences between France and Belgium with a view to making it easier to obtain supplementary qualifications.

Czechoslovakia has concluded various agreements with other Socialist countries.

Finland has concluded general agreements (not limited to higher technical education) for an exchange of students with the other Scandinavian countries, Bulgaria, Czechoslovakia, France, the German Democratic Republic, Hungary, Poland, Romania and the U.S.S.R. This country also has general agreements for an exchange of trainees with Austria, Belgium, France, Italy, the Netherlands and Switzerland. Semi-official agreements to the same end have been concluded between the Finnish Ministry of Labour on the one hand, and Canada, the Federal Republic of Germany, the United Kingdom and the United States of America on the other.

France has concluded agreements with the French speaking States in Africa as well as certain States of Latin America and elsewhere, to receive trainees at practical courses, on behalf of the Ministry of Industrial and Scientific Development and the Ministry of Economics and Finance, at courses held by the Agence pour la Coopération Technique, Industrielle et Économique (ACTIM) which forms part of the Ministry of Economics and Finance. The same agency provides the practical training courses organized by UNIDO for professional staff who have held posts of responsibility.

The *Netherlands* and *Belgium* have concluded an agreement on the mutual recognition of examinations held by the technical faculties of Belgian universities and those of the Netherlands.

Norway has concluded the following special agreements. (a) for education in aeronautics, an agreement between the Norwegian Institute of Technology and the Royal Technical University of Sweden, Stockholm, on the admission of Norwegian students to the latter, (b) for education in petroleum technology, between the Norwegian Institute of Technology and two foreign universities, one in Austria and the other in the Federal Republic of Germany.

Sweden has regulations which take into account previous examinations taken at universities in other Scandinavian countries.

These few examples show that agreements on the education and training of engineers are still far from being the general rule, even in the case of a relatively restricted group of countries such as the European Economic Community or the Scandinavian group of countries.

It may be useful to give some details, by way of information, on the work of the EEC in this field and the results obtained so far.

Title III of the Treaty of Rome deals with 'The Free Movement of Persons, Services and Capital'.

Article 48 of the treaty stipulates that:

1. The free movement of workers shall be ensured within the Community ...
2. This shall involve the abolition of any discrimination based on nationality between workers of the Member States as regards employment, remuneration, and other working conditions ...

Article 57 includes this provision:

1. In order to facilitate the engagement in and exercise of non-wage-earning activities, the Council, on a proposal of the Commission and after the Assembly has been consulted, shall ... act by issuing directives regarding mutual recognition of diplomas, certificates and other qualifications.

Thus Article 57 lays on the EEC the obligation to establish directives regarding mutual recognition of 'diplomas, certificates and other qualifications' of professional workers (including senior technologists).

The Commission might have envisaged various ways of solving the problem. A completely logical solution might have been to standardize different levels of training in the various countries, but it can be assumed *a priori* that such a solution would have been utterly impractical, at least in the short and medium terms.

The draft directives elaborated by the Commission embodied, on the contrary, the idea of over all criteria, a kind of common denominator acceptable to all the countries concerned, being briefly the criteria of the level required for admission to post secondary education, and the duration and level of post secondary education (university or similar, higher technical, technical).

It should be stressed that the draft directives were devised and formulated in the context of a community which at that time comprised only six European countries. Since January 1973 there have been nine member countries, including the United Kingdom and Ireland, where, as we have seen, the education system differs, at least in form, from the so-called 'Continental system'. It can therefore be assumed that while the basic concepts of the draft directives remain valid, their legal formulation will probably have to be amended to take account of this difference in viewpoint. In any event, and very generally speaking, the draft directives not yet approved by the council will have to be reviewed to take account of the viewpoints of the three new EEC members. Further, the Commission's draft directives will have to be approved subsequently in any case by the Council of Ministers, where individual national attitudes may act as a barrier to the aims and proposals of the Commission.

In conclusion, it will be noted that the trends within the EEC Commission are in line with those of the FEANI register, namely failing the possibility of achieving complete standardization, the question should at least be clarified by drawing up appropriate categories making reference to over-all criteria. Noteworthy also are the two basic differences between the FEANI register and the EEC directives. (a) the latter are in the form of regulations, whereas the register is an initiative freely taken by the engineering profession, (b) on the other hand, the EEC regulations apply to only nine countries, whereas the FEANI register has been approved by the professional associations of eighteen European countries.

We shall return to this problem and the possible methods of solving it in the conclusions contained in Section 9.1.

8 Relationships between engineering and other professions

8.1 Relationship with architects

In many countries the education of architects is somewhat similar to that of engineers. In such cases the pursuit of the profession of architect by an engineer raises no specially difficult legal or practical problems. Numerous individual cases of this general problem do, however, exist.

In *Austria*, the *Diplomingenieure* who graduate from faculties of architecture in the *Technische Hochschulen*, or technical universities, tend to be more suited to the technical side of civil engineering. They represent two-thirds of the personnel in large architects' firms. *Magisterarchitekte* (master of architecture) graduating from academies tend mostly to choose the artistic side.

In *Belgium*, architects follow a five-year course, after six years' primary and six years' secondary education, in institutions which are run either by the State, the provinces or the communes, or else are subsidized or recognized by the State. Their diploma is awarded either by these institutions or by a central board of examiners. As already observed in Section 3.3 above, civil engineers specializing in architecture (*ingénieurs civils architectes*) take a five-year course in faculties of applied science.

The Law of 26 June 1963, establishing a professional association of architects (Ordre des Architectes) in Belgium, requires that civil engineers who graduate after that date follow a two year practical training before being entitled to sign, in their capacity as architects, plans for technical work which are solely within the competence of a graduate engineer. Graduates of civil engineering departments of universities who have specialized in architecture are naturally not subject to this restriction.

In *Finland*, there is no official distinction between the functions of an engineer and those of an architect, though in fact the specialization does exist.

Graduate architects from university faculties of architecture specialize in planning buildings and regional planning, while graduate engineers from engineering faculties specialize, as the case may be, either (a) in the practical execution of projects, calculation of the strength of materials, supervision of construction stages, public works—in the case of former students of civil engineering faculties, or (b) heating, plumbing, ventilation—in the case of former students of mechanical engineering faculties.

Architects and engineerings graduating from civil engineering branches of technical colleges in Finland (category L) specialize respectively in the planning of buildings and town planning, and actual construction work.

In *France*, architects must be members of the professional association (Ordre des Architectes) to be entitled to use the qualification of architect and pursue the profession. There is, however, no professional association of engineers and, as observed above, the plain qualification of engineer is not protected by the law, nor is the engineering profession the subject of regulations Thus the only qualifications which are protected are those of graduate engineers from schools empowered to award diplomas by the Commission des Titres d'Ingénieur of the French Ministry of Education.

Consulting engineers, in full agreement with the ministries concerned, refuse to entrust the over-all responsibility of work to architects alone. An agreement on the pursuit of their profession was signed in 1957 between the Ordre des Architectes and the Chambre des Ingénieurs-Conseils.

In the *Federal Republic of Germany*, some *Lander*, for example North-Rhine-Westphalia, have statutory associations of architects with which it is necessary to register in order to practise the profession of architect.

In *Greece*, recognition as an architect, and the right to pursue the profession, are restricted to graduates of a technical university (Dipl.Ing.Arch.) in much the same way as for engineers in other special branches. Where complex structural calculations have to be done, the architect must work in conjunction with a graduate civil engineer, who is legally responsible for the safety of the construction. The engineer receives 60 per cent of the fee for the calculations, leaving only 40 per cent to the architect.

In the *Netherlands*, a law is being drafted on the qualifications of architects, a register of architects exists, but registration is not compulsory, graduate architects of a university are exempt from the examination for admission to the register.

In *Switzerland*, in the absence of legal provisions, professional practice is regulated for both professions by the regulations and standards of the SIA (Société Suisse des Ingénieurs et Architectes). There is an excellent degree of alignment between the two professions (for example, the qualification of *architecte-technicien* corresponds to that of *ingénieur-technicien*, etc.).

In the *United Kingdom*, there is no legal dividing-line between the professions of engineer and architect, but in practice specific functions are reserved for each profession For instance, the building of reservoirs and dams is reserved for those engineers who are on a special register.

Depending on their form, building contracts are drawn up either by the Institute of Civil Engineers or by the Royal Institute of British Architects.

8.2 Relationship with agronomists

Engineer/agronomists are usually put in the same category as engineers in other branches They graduate either from the same technical universities, where they are enrolled in other faculties, or from separate schools of agronomy.

To give a very detailed example of their education, in *Belgium* there are two degrees, that of engineer/agronomist and that of engineer in the chemical

engineering and agricultural industries. Both of these degrees comprise a two-year preparatory course (*candidature*) covering mathematics, chemistry, biology, earth sciences and an introduction to the humanities, followed by a three-year course for the degree proper as follows:

1. *For the Belgian engineer/agronomist's degree.* (a) the following six common subjects. advanced biology, soil and environmental sciences, plant and animal production, engineering techniques, industrial processing of natural products, economics, (b) a comprehensive study of one of the following fifteen special subjects. general agronomy, agronomy of tropical and sub-tropical regions, stock farming, plant technology, forestry, horticulture, plant protection, agricultural engineering, rural economics and sociology, rural economics and sociology applied to developing countries, land development, soil sciences, applied botany, applied zoology, nutrition and dietetics, (c) a terminal study of the subject which has been studied in depth.
2. *For the Belgian degree in chemical engineering and agricultural industries.* (a) the following eight common subjects. theoretical and physical chemistry, analytical chemistry, organic and biological chemistry, agricultural chemistry and physics, industrial biology and microbiology, industrial physics, engineering techniques, technology and management of food and agriculture industries, (b) a comprehensive study of the basic and applied aspects of one of the eight subjects above or of the technology of an agricultural industry, (c) a terminal study of the subject which has been studied in depth.

8.3 Relationship with 'scientists'

By simplifying somewhat, it may be assumed that a 'scientist', for example the holder of a French *licence* in physics, or a doctor in chemistry, has received very substantial theoretical education, more than that of an engineer, but that, on the other hand, his practical training has been comparatively limited. These two types of education usually lead to different professions. In *Belgium*, for example, there exist on the one hand the *licence* and the doctor's degree in chemistry, and on the other hand the diploma in chemical engineering, which lead to two different careers.

Nevertheless, in the course of his career, as he gradually comes into contact with practical work, the holder of a *licence* in chemistry may acquire through the actual pursuit of his profession the practical training he lacked when he obtained his *licence*.

This case has been provided for in the FEANI register under Group A, Section Aa, with the following definition:

> Persons having acquired a complete scientific university education and training [in France, for example. complete *licence*] and having practised the profession of engineer for at least two years A jury will decide, in each individual case, if the degree of the scientific faculty in question can be recognized, and if the period of practising the profession of engineer suffices.

There is no doubt that what is meant here is a scientist who has moved into the professional category C (conception) and has been recognized by FEANI as belonging to that category.

8.4 Relationship with economists

An example of technico-economic education is provided by the *Wirtschafts-diplomingenieure* educated by some *Technische Hochschulen* in the *Federal Republic of Germany* (in particular, that of Berlin-Charlottenburg). These 'graduate engineers in economics' receive a basically economic education, but are in addition obliged to specialize by taking courses which are, incidentally, of the same duration as for the other *Diplomingenieure*, namely an average of five and a half years, including a terminal study in a specialized technical field of their own choice. This special subject is sometimes computer science (including both hardware and software), or even automatic control. This enables *Wirtschaftsdiplomingenieure* on leaving the university to select a career in general business organization and management or even integrated automation, using the same computer for the management of administration, finance and accounts and for the automatic control of industrial processes.

Two other examples of technico-economic education may be quoted in *France*, the first being the courses provided by the CNAM (Conservatoire National des Arts et Métiers). Among the engineering diplomas awarded by the conservatoire in many special branches is that of *ingénieur CNAM*, with specialization in 'scientific labour management'. Like all the others, this CNAM diploma requires, before the general examination and the defence of a thesis, certificates attesting to the successful completion of courses and practical work in three different fields, comprising that of the special subject chosen, called the main field, and two other fields, called related fields. In the particular case of the CNAM engineering diploma with specialization in scientific labour management, one of the two related fields must be of a technical or scientific nature.

The second example is that of the *diplôme d'études économiques supérieures* (higher economic studies diploma) awarded by the same establishment. Most of these diplomas are awarded in subjects which are somewhat remote from the engineering field, such as, for example, insurance, commercial law, economics and banking techniques, the history of labour and industrial relations, the organization and operation of financial markets, the physiology of labour, vocational selection and guidance, financing and accounting techniques in business, etc.

However, certain other special subjects for the CNAM higher economic studies diploma, less remote from the engineering field, require some studies of a technical nature. In this connexion the following examples may be quoted: (a) the 'history of building', for which a certificate attesting to successful completion of a technological course is required (civil engineering, chemistry applied to materials, industrial heat technology), (b) 'economic geography', for which a certificate attesting to the successful completion of a

scientific or technological course is required (agriculture, industrial chemistry, spinning and weaving, metallurgy, industrial electricity), (c) industrial and statistical economics', with a compulsory one-year course in a technological subject chosen by the candidate.

In *Belgium*, there is an educational course and diploma for commercial engineers', on the same lines as those quoted above.

Unlike those 'scientists' who may become real engineers by acquiring in industry the practical experience they lacked, it can be seen that the economists described above do not receive, either during or after their studies, the theoretical education and practical training that could qualify them for one of the categories of higher technical professions. Obviously this is a question, not of level, but of type of career.

8.5 Interdisciplinary work

When speaking about interdisciplinarity, a clear distinction should be drawn between interdisciplinary education on the one hand and the interdisciplinary practice of a profession (or group of professions) on the other. The former is an educational matter, whereas the latter concerns the use of an interdisciplinary team to solve problems of varying degrees of complexity arising from the practice of a profession or a group of professions

The majority of national associations of engineers to whom the question was put deplore the virtually total absence of interdisciplinary education in schools.

This does not imply the absence of interdisciplinarity in the broadest sense of the term. Biology is not taught in engineering schools, and only little time—sometimes too little—is given to psychology, economics, organization and management. It is not, therefore, a question of expecting institutions to produce engineers who are also experts in the combined fields of psychology, biology, economics, organization, management and technology, at most, it is a question of giving engineers, in the broad sense of the term 'interdisciplinarity', the ability and taste for working, when necessary, after they graduate, with psychologists, biologists, economists, organizers and management specialists.

The criticism of the lack of interdisciplinarity in enginering schools thus refers to a narrower aspect of the term. The engineering student usually receives a thorough grounding in mathematics, physics, chemistry, mechanics and the engineering sciences. However, he receives very little instruction as to how to weld this knowledge into a whole with a view to solving specific problems of the type he will meet after graduating. It is in this narrower sense of a lack of education in taking the over-all view that one should interpret the almost unanimous criticism directed against the lack of interdisciplinarity in the education imparted by the majority of engineering schools.

There is also criticism in relation to another aspect, equally essential for the student embarking on an engineering career. that of the development of creative ability, closely linked with the ability to take an over-all view of the knowledge acquired.

Many methods have been proposed—and sometimes put into practice—for developing from school onwards the future engineer s creativity and ability to take an over-all view.

The most usual method is that of introducing projects during the course, or an end-of-course project. The effectiveness of projects during the course (and, in some schools, of an end-of-course project) is greatly reduced by the fact that they are carried out in small groups, which of course develops the ability to work in a team but at the same time takes away from the value of the individual effort. The end-of-course project (an individual one in most schools) has the opposite advantages and drawbacks, and has occasionally the additional defect of being too theoretical. Here the ideal, for both group and individual projects, is obviously to choose a realistic subject, taken from industry, and devised in addition to serve as a basis for a practical, economically feasible project.

At all events, projects have for some time now been making a noteworthy, if as yet insufficient, contribution towards the interdisciplinary education of engineers. The examples in France of both State and private *écoles des arts et métiers* is typical in this respect, the addition of a fourth year of studies—largely devoted to practical projects stemming from industry—has considerably widened the horizon of the engineers who graduate from them, by giving them a professional qualification distinctly superior to that of earlier graduates, whose course lasted only three years.

Another idea for developing creativity and the ability to take an over-all view of knowledge acquired would be to introduce into the curricula of engineering schools, following the basic scientific education (mathematics, physics, chemistry, mechanics) and as a substitute for certain engineering sciences of an encyclopædic nature (such as electrical engineering, heat technology, metallurgy, etc.), engineering sciences of a more phenomenological nature.

As their name indicates, such engineering sciences would dwell at greater length on the study of a given phenomenon recurring in various technological fields, rather than a succession of more encyclopædic studies of various technological fields each of which is taken as a whole. An example of such a phenomenological study might be provided by the study of the phenomenon of plasticity found not only in metallurgy (plasticity of metals at high temperatures) but also in the technology of building materials (plasticity of cement at ambient temperature) and fluid mechanics (plasticity or viscosity, of liquids), not to mention the technology of plastics (resistance to extrusion), paper manufacturing (the 'consistence' of pulp), etc.

However attractive at first sight, the application of this idea in practice comes up against teaching difficulties. The fact is that the number of known phenomena which lend themselves to the teaching of the phenomenological sciences of engineering is not enough to cover the vast field of knowledge which is at present well covered by a succession of more encyclopædic studies of various technological fields, each of which is taken as a whole.

A very interesting idea—and one which can quite easily be put into practice—is to introduce into the curricula of engineering schools what is now called by general agreement 'systems science' or, in a more restrictive sense,

systems engineering'. This study leads not only to a new way of thinking but also to new working habits and knowledge of what is in fact a new science

The new way of thinking ('systems approach') consists in regarding a more or less complex system—technological, biological or economic—not as a group of components of which one seeks to know in detail the individual characteristics and interactions, but as an entity to be distinguished by its over-all behaviour, irrespective of that of its constituent parts. This approach, which of course requires methods very different from traditional ones, proceeds, unlike the latter, from definitely synthetic, and not analytic, thinking. The use of the systems approach in schools can, therefore, lead only to the development of a synthetic and creative turn of mind, which is not particularly encouraged by the current analytic approach.

Accustomed to working, from the engineering school onwards, on over-all (and relatively complex) technological problems, which he is able to master thanks to the education imparted by the school, the engineer will find it only natural on leaving school to continue to work in a team, on over-all problems which are still more complex and which he will no longer be able to master on his own. The extraordinary flexibility of the systems approach, which allows of continually passing from the simplest to the most complex group, would thus enable the engineer to pass almost imperceptibly from the most narrow aspect of interdisciplinarity at the engineering school to its broadest aspect in his professional life. After having worked at school on the over-all aspects of relatively simple technological systems, on leaving school, he will work with other engineers on more complex technological systems, and subsequently, when necessary, with psychologists, biologists, economists, organizers and management specialists, on the still more complex systems of the everyday world.

The new science itself, systems science, has many aspects, not all of which need necessarily be taught in detail in an engineering school. They include the following, which we list for the sake of clarity:

The over-all *identification* of an unknown system, by observing its over-all behaviour in relation to certain appropriate stimuli or tests, with a view to constructing a simplified mathematical model of the actual system observed.

The *sensitivity* of the system to a specific cause among the many possible causes influencing its behaviour with a view to detecting the causes to wich it is particularly sensitive and being able to apply the most effective remedy to undesirable effects by acting on its 'sensitive points', this is, moreover, the normal biological behaviour of any living being, which reacts quickly in the first place to any harmful influence by means of its most efficient organ, and then terminates its response in a more balanced fashion by means of several of its appropriate organs simultaneously.

The *hierarchy* of a system, by distinguishing between low-level control elements, responsible for rapid and effective responses requiring relatively simple decisions', and high-level control elements, which make more complex 'decisions' requiring more time and thus leading to slower responses.

The mathematical background required by systems science is of a level

which is fully compatible with that of the mathematical knowledge of a student at a modern engineering school. This knowledge would be more than sufficient for a study at school of the rudiments of systems science, introduced for essentially educational purposes. The subsequent extension of this knowledge by means of continuing education would enable the engineer to participate, when necessary, in the solution of highly complex problems by making use of computer science, automatic control or operational research methods.

Setting aside the powerful instrument for interdisciplinary education and training, both at school and afterwards, which an appropriate introduction to systems science would provide, there are at present three different ways of acquiring interdisciplinary education during the course of a professional career:

1 Contacts with other engineers in working groups, while taking part in continuing education, or while exercising the profession, contacts with colleagues, supervisors and subordinates which lead to acquiring a broader outlook than that acquired at school.
2 Moving from one type of work to another in a succession of posts with the same firm, or with different firms (mobility). Such mobility obviously requires a sound general education at school and the acquisition of the ability to 'learn to learn'.
3 As a result of promotion, the engineer may acquire a more comprehensive, and less specialized (less specifically technical) outlook. He is thus obliged to pay more attention to the problems of management, financing, personnel, social psychology, marketing, sales, etc., than to purely technical problems.

In *Denmark*, the two Danish associations of engineers (categories C and L) organize interdisciplinary courses in medical technology, town planning and urban economics, business management, etc.

In *Finland*, 50 per cent of graduate engineers are employed in administration and planning.

In *France*, socio-economic surveys conducted in 1967 and 1971 show that from the age of 40 onwards, roughly one-half of graduate engineers perform functions which go beyond the purely technical, such as the management of industrial firms (the usual culmination of their career), commerce, banking and insurance.

Several channels for continuing education in management are reserved for this purpose and used by a large number of engineers, these include the Institut d'Administration des Entreprises (IAE), courses held by the Paris Chamber of Commerce, etc.

In *Norway*, many heads of industry are engineers. However, there is a widespread drive to provide interdisciplinary training for engineers, if not at school, at least thereafter.

9 Conclusions

9.1 The common denominators of the 'Continental' and 'British' systems

In Section 1 2 we defined three categories of professional technologists. category C (conception engineers), category L (liaison engineers and senior technicians), and category E (execution technicians).

We also saw that the over-all characteristics of these three categories fitted satisfactorily into the 'Continental system' (based on primarily academic criteria as expressed in diplomas awarded by universities or schools), with the over all characteristics of entrance requirements and the duration and level of studies as indicated in both the Draft Directive No. 2 established by the Commission of the European Economic Community and the FEANI *European Register of Higher Technical Professions*. Thus. (a) category C fits in with both section 1 of the draft directive and category Aa of the register, (b) category L fits in with both section 2 of the draft directive and categories Ab and Ba of the register, (c) category E fits in with section 3 of the draft directive, though it has no equivalent in the register, which is reserved for the time being for higher technical professions only.

Next, in the 'British system' (based on primarily professional criteria as approved by professional institutions), with the three respective categories of chartered engineer (category C), CEI technician engineer (category L) and CEI technician (category E).

The primary difference between the 'Continental system', prevailing in sixteen out of the eighteen FEANI countries, and the 'British system', which prevails in the United Kingdom and Ireland, is as follows.

The former, based on essentially academic criteria, necessarily involves, in addition to the definition of the level of knowledge acquired, that of entrance requirements (and therefore the duration of secondary schooling) of universities or schools, and the duration of studies thereat.

The latter, based on essentially professional criteria, requires only the definition of the level of knowledge acquired, to which should be added that of certain professional requirements (in particular, a minimum period of professional experience before gaining the right to assume a professional qualification). It does not involve criteria for the duration of either secondary education or post secondary studies (though the age limits indicate that some maturity is required).

This difference might give rise to difficulties in the formulation of legal definitions of the various categories of professional technologists.

As for the substance of the problem, the example of a practical achievement, at the non-governmental level, provided by the *European Register of Higher Technical Professions*, instituted by the professional associations of the eighteen member countries of FEANI, shows clearly that the two systems undoubtedly have common denominators.

This register is based on the following main considerations.

The decisions of the national register office of any one of the eighteen FEANI countries are recognized—except in the event of an appeal, in disputed cases, to the Register Committee—by the national register offices of the other seventeen countries.

In conformity with this principle, each of the national associations which are members of FEANI submits to the Register Committee the list of schools in its country which, in its opinion, are empowered to award diplomas in this or that professional category, this list is finally approved by the Register Committee, i.e. by the eighteen national associations as a whole.

Also according to this principle and with particular reference to professional technologists without any formal qualifications ('self-educated'), each national register office is entitled to make such technologists take a professional examination before a board of specialized examiners, and to enter them, if they pass, in the appropriate professional category, these decisions are binding on the national register offices of the seventeen other countries;

The situation on the United Kingdom and Ireland is somewhat similar to that of the 'self-educated' in the sixteen 'Continental' countries of FEANI, though with this difference, that it is the general rule with the former, and the exception with the latter.

This last remark calls for reflection, as it shows clearly that the apparent differences between the 'Continental' and British' systems are differences of form rather than of substance, and that in fact the two systems have common denominators.

9.2 Possibilities of applying the European experiment of FEANI to other continents

We have seen that:

First, the structure of the engineering professions in Europe comprises—for sixteen of the eighteen FEANI countries, i.e. excepting Italy and Czechoslovakia—three separate categories of professional technologists. conception (C), liaison (L), and execution (E).

Second, this ternary structure comprises the possibility of a certain difference of levels between schools within each of the three categories, since they are defined by minimum over-all criteria and not by hard and fast rules. It is in fact the idea of the 'common denominator' which makes possible the mutual recognition of qualifications resulting from the education provided in various countries at a given time. A certain amount of flexibility in the

definition of criteria also makes it possible to take into account trends in education over a period of time. The level of a school may vary slightly from time to time without its graduates changing their professional category on that account.

Third, in the event of a more important change in the level of a given school, its graduates may have to be classified in another category, without the structure of the technical professions as a whole being modified thereby. An example of an important change of this kind is to be seen in Spain, where schools which now educate *ingenieros tecnicos industriales* corresponding to category L, formely educated *peritos industriales*, corresponding more closely to category E.

Fourth, Continental and British systems which, moreover, also exist outside Europe, have common denominators, notwithstanding their apparent differences.

This all goes to make the 'European system' a single and coherent whole, despite apparent differences, which are chiefly those of form.

This system could therefore be applied, at least qualitatively, to countries situated outside Europe.

It is however obvious that from the quantitative point of view, the numerical distribution of professional technologists between the three categories—C (conception), L (liaison) and E (execution)—which already varies fairly widely from one European country to another, might vary still more widely in certain countries outside Europe.

The optimum numerical distribution does not follow, *a priori*, any general rule, and should be considered separately in each particular case. Appraisal factors which might influence it include the following:

The current economic situation of the country under consideration, of course taking foreseeable trends into account. Trends in the desirable distribution of professional workers between the three categories should obviously be slightly in advance of foreseeable economic trends, they should not lag behind or even be too much in advance, since this might be liable to upset the balance between availabilities within categories and the opportunities for making the best possible use of them, such lack of balance would, of course, in turn be detrimental to the subsequent economic development of the country concerned.

The quality and quantity of skilled manpower available. The existence of large numbers of good skilled workers makes the settling down process very much easier for professional technologists joining industry, it simplifies their practical training problems correspondingly and facilitates their integration in industry. A shortage of skilled manpower might make it desirable to have a rather larger proportion of category E execution technicians, and even of category L liaison engineers and senior technicians, in order to supervise and train existing manpower.

It is necessary to consider the existing situation in a given country. The optimum distribution of professional technologists by category should not be defined globally but for each branch of industry. For example, Belgium which has usually a fairly high proportion of category C conception engineers does not produce either aircraft or automobiles. Hence the

proportion of conception engineers required in the aircraft and automobile sectors is normally smaller than in other industrial sectors in Belgium. The chief requirement in Belgium for the aircraft and automobile sectors is category L liaison engineers and senior technicians, and above all, category E execution technicians to service and maintain foreign-produced aircraft and automobiles, the situation is obviously very different in the chemical industry or metallurgy.

The existence of associations of engineers and learned societies which are of relatively long standing, with well-established traditions and a sound organization is a specially important factor for. (a) a reliable professional qualification for new generations of technologists—this becomes a basic consideration where the professional qualification is the concern of the associations of engineers or learned societies themselves (as in the 'British system') and not of universities and schools (as in the 'Continental system'); (b) the proper organization of continuing education, (c) the efficient supervision of the practical training of professional technologists, except where such supervision is entrusted to universities and schools.

Appendix

National monographs on the eighteen member countries of FEANI

Austria

After four years' primary education at the *Volksschule*, the Austrian pupil has a choice of two types of secondary education. (a) a more traditional type (*Gymnasium*), leading on completion of eight years' secondary education to the secondary school leaving certificate which gives access to university education, (b) a more modern, practical type (*Hauptschule*), leading on completion of four years' education to the lower secondary school leaving certificate.

Diplomingenieure are educated at the *Technische Hochschulen* (technical universities) of Vienna and Graz, the Mining and Metallurgical College, Leoben, the State College of Agriculture, Vienna, and the Faculty of Civil Engineering and Architecture of the University of Innsbruck, to which they are admitted on leaving the *Gymnasium* (i.e. on completion of twelve years, primary and secondary education), with in some cases an additional entrance examination.

As regards particularly the *Technische Hochschulen*, the course lasts ten semesters (five years), with the following special subjects. industrial chemistry (mineral and organic chemistry, biochemistry and the chemistry of food products, engineering chemistry), in which the student specializes on completion of the fifth semester of common subjects, mathematics (physics-oriented, economics oriented, data processing), with specialization on completion of the fourth semester of common subjects, computer science, architecture (civil engineering and town planning, building and interior design, general architecture and surveying), with specialization on completion of the fourth or sixth semester of common subjects, topography and geodesy, industrial sciences (workshop technology, boilers and reactors, piston engines, fluid engines, continuous processes), with specialization on completion of the fourth semester of common subjects, electrical engineering (high intensity currents, industrial electronics, telecommunications), with specialization on completion of the fourth or sixth semester of common subjects.

The courses in all the establishments in this category lead to the qualification of *Diplomingenieur*.

Ingenieure are educated in technical colleges (*Technische Mittelschule*) to which they are admitted on leaving the *Hauptschule* (i.e. on completion of eight years' primary and secondary education). They remain there for five years and obtain the qualification of 'engineer', which in some cases gives access to university education. The engineer is however finally confirmed only after four years' practical experience in industry.

Technicians are educated in vocational schools, to which they are admitted on leaving the *Hauptschule* (i.e. on completion of eight years' primary and secondary schooling) and where they take a four year technical course.

The Federal Law of 10 July 1969 regulates the use of the university degree of *Diplomingenieur*, and the Federal Law of 7 July 1948 regulates the use of the qualification of 'engineer'. As has already been seen above, the latter corresponds to a total of thirteen years, primary, secondary and technical education, followed by four years' practical experience. A recent law which

came into force on 1 January 1973 established an Austrian register of engineers.

The *Technische Hochschulen* come under the Federal Ministry of Science and Research, while the federal institutions of technical education (*Technische Mittelschulen*) come under the Federal Ministry of Education and the Arts.

The *Lander* schools come directly under federal ministries. Private schools are independent but they receive assistance from the State (such as, for example, the supply of teachers).

The curricula of technical education institutions are defined by a decree of the Federal Ministry of Education and the Arts, and their application is supervised by *Lander* inspectors. General educational supervision is carried out by the governing boards of the *Lander* schools

Industry examines changes in curricula before they are introduced, and states its requirements to the governing bodies of technical education institutions.

Austria has concluded an agreement with the Federal Republic of Germany for the mutual recognition of engineering qualifications.

Diplomingenieure graduating from the faculties of architecture of the *Technische Hochschule* tend for the most part to go in for the technical side of building, and represent two-thirds of the personnel of large architects' firms *Magisterarchitekte* (masters of architecture) graduating from academies tend rather to choose the artistic side.

Belgium

After six years' primary education, the Belgian pupil has a choice between two types of education (a) secondary education ('humanities') lasting six years, (b) technical education, also lasting six years.

Ingénieurs civils are educated in the faculties of applied sciences or agricultural sciences of a university, except for. (a) the Polytechnic Faculty at Mons, which comes under the Province of Hainault, (b) the State Faculty of Agricultural Sciences at Gembloux, which comes directly under the State. These two faculties will shortly become part of an existing university. Universities are either State institutions (Liège, Gent), coming under the Belgian Ministry of Education and Culture, or private institutions (Brussels, Louvain), and therefore autonomous.

Ingénieurs techniciens are educated in schools for technician engineers, which are separate from the universities

The entrance requirement for both universities and schools for *ingénieurs-techniciens* is the secondary-school leaving certificate (humanities), including the following science subjects. basic mathematics (plane and solid geometry, analytical geometry, algebra, elementary differential and integral calculus, arithmetic, rectilinear and spherical trigonometry, descriptive geometry, numerical calculus), science (physics, chemistry and biology), drawing.

The qualifications of *technicien supérieur, technicien gradué, conducteur technique* or *assistant d'ingénieur* is conferred by appropriate schools which are separate from the universities

The entrance requirements are slightly lower than for *ingénieur civil* and *ingénieur-technicien*.

The course for *ingénieurs civils* consists of two cycles spread over at least five years, comprising (a) a two-year cycle *candidature* leading to the certificate of *candidat ingénieur civil* or *candidat ingénieur agronome*, (b) a three-year cycle leading to the degree of *ingénieur civil* or *ingénieur agronome*.

Ingénieurs-techniciens are educated in higher secondary technical establishments. Their studies last three or four years, depending on the school.

The *technicien supérieur, technicien gradué, conducteur technique* or *assistant d'ingénieur* is at present trained in higher technical short-cycle schools (in application of the Law of 7 July 1970), whereas formerly this training took place in higher primary technical schools.[1] Education consists of a two-year course with emphasis on practical work (22 per cent of the time is devoted to basic technical-scientific education).

Techniciens are educated in various branches of secondary technical education, in appropriate institutions set up by the State, the province, the commune or privately.

A distinction can be drawn between two levels. (a) the lower secondary cycle, comprising in theory four years, plus a year of further education as necessary, the entrance level being that of the primary-school leaving certificate, (b) the higher secondary cycle, reserved normally for pupils who have satisfactorily completed the third year of the lower secondary cycle, it comprises three years plus an optional one-year course in a special subject or further education as necessary.

Education at the *candidature* level for the diploma of *ingénieur civil* (first cycle, two years) comprises the following subjects. analytical geometry, descriptive geometry, applied descriptive geometry, higher algebra, differential calculus, integral calculus, introduction to the calculus of variations and the calculus of finite differences, analytical mechanics, graphic statics, elementary astronomy and geodesy, general physics and elementary theoretical and mathematical physics, general chemistry and elementary physical chemistry, introduction to the theory of probability and the theory of observational errors.

Whatever their special subject, future *ingénieurs civils* take the following common subjects during the second cycle of the course (lasting three years). natural materials used in industry (mineralogy, geology, mining geography, elementary analytical chemistry), the use of natural materials and the production of artificial materials (fuels, metals, natural and artificial stone, timber, industrial materials) which calls for a knowledge of general metallurgy, iron and steel making, metallography, the use of fuels, industrial chemistry and general construction engineering processes, applied physics and

[1] The law of 7 July 1970—which has still to be supplemented by a second law—provides for (a) long higher technical education at university level, with two cycles or a second cycle organized separately from the first, (b) short higher technical education consisting of one cycle By cycle is meant a course lasting at least two years

mechanics (elasticity, resistance of materials, notions of the stability of structures, hydraulics, thermodynamics, kinematics and the dynamics of machines, electricity and its industrial applications), mechanical and industrial engineering (technology, description and construction of machines, industrial plants, the rudiments of topography), political and social economy and an introduction to industrial law.

The nine specialities open to *ingénieurs civils* call for a study of the following special subjects:

Mining further courses in mineralogy and geology, palaeontology, topography, including underground topography, mine working, a further course in metallurgy, applied geology.

Civil engineering building and civil engineering, a further course in the stability of structures, a further course in hydraulics, architecture and the history of architecture, topography; railroad working.

Metallurgy a further course in analytical chemistry, a further course in industrial chemistry, physical chemistry, including thermochemistry and electrochemistry, a further course in metallurgy (iron and steel, and non-ferrous metals), including electrometallurgy, a further course in metallography.

Chemical engineering a further course in analytical chemistry, a further course in industrial chemistry, physical chemistry.

Electrical engineering railroad working, electricity and its industrial applications (advanced course).

Mechanical engineering railroad working, a further course in the construction of machines, electricity and its industrial applications (a further course).

Shipbuilding a further course in the stability of structures, a further course in hydraulics, theory of ship design, shipbuilding and marine technology, boilers, naval and auxiliary engines.

Architecture civil architecture and the history of architecture, a further course in the stability of structures, evaluation of earthworks, bridge building, ways of executing various types of work, building legislation, architectonic composition, topography.

Textiles study of textile fibres, special technology of spinning, special technology of weaving, study of colouring matters, special technology of dyeing; special technology of fabric finishes

Whatever the special syllabus chosen, the course qualifying for the degree of *ingénieur civil* includes the preparation of a terminal project.

On completion of a further one-year course, an *ingénieur civil* may obtain a university degree in one of the following twelve special subjects. geology, operational research, physics, applied mathematics, hydraulic works and hydrography, radioelectricity, town planning, industrial management, applied nuclear sciences, petrochemistry, geotechnics, automatic control.

As regards agricultural engineering, Belgium has the following two degrees of *ingénieur civil*: *ingénieur civil agronome* and *ingénieur civil chimiste et des industries agricoles*.

The two-year *candidature* course for these degrees includes the study of the following subjects. mathematics, chemistry, biology, soil science, introduction to the social sciences.

The course for the degree of *ingénieur, civil agronome* (three years) includes.

1 The following common subjects. advanced biology, soil and environmental sciences, plant and animal production, engineering techniques, industrial processing of natural products, economics.

2 A comprehensive study of one of the following fifteen subjects. general agronomy, agronomy of tropical and subtropical regions, stock farming, plant technology, forestry, horticulture, plant protection, agricultural engineering, farm economics and sociology, farm economics and sociology applied to developing countries, land management, soil science, applied botanics, applied geology, nutrition and dietetics.

3. A terminal study on the subject which has been studied in depth.

The course for the degree of *ingénieur civil chimiste et des industries agricoles* (three years) includes:

1. The following common subjects. theoretical and physical chemistry, analytical chemistry, organic and biological chemistry, agricultural chemistry and physics, industrial biology and microbiology, industrial physics, engineering techniques, technology and management of food and agricultural industries.

2 A comprehensive study of the basic and applied aspects of one of the above-mentioned eight subjects or of the technology of an agricultural industry.

3. A terminal study on the subject which has been studied in depth.

The right to use the designation of *ingénieur civil* or *ingénieur-technicien* is regulated by the Law of 11 September 1933 on the protection of qualifications in higher education.

On the other hand, the qualifications conferred by the short cycle of higher technical education (*technicien supérieur, technicien gradué, conducteur technique. assistant d'ingénieur*) are not protected.

University institutions are governed by a board of directors on which the government is represented. Their financing and supervision are regulated by the Law of 27 July 1971.

Curricula are defined by legislation on academic degrees and the programme of university examinations.

The supervisory ministry is the Ministry of Education and Culture.

The requirements of industry are stated to the university by means of a body known as the Fondation Industrie-Université.

Ingénieurs-techniciens may obtain the degree of *ingénieur civil* after a three year additional course. Only 1 per cent of them choose this way of advancing in their profession.

Belgium also has what is known as a *jury central*, or central examining body. Self-educated persons may acquire a diploma or certificate without regularly attending formal courses, provided that they give evidence of a corresponding level of theoretical and practical knowledge before such a central examining body.

Equivalences have been legally established between the academic degrees awarded in Belgium and territories formerly subject to Belgian sovereignty or entrusted to Belgian administration, they are now being revised.

The faculties of applied sciences reserve the right to test the level of knowledge acquired abroad and to make sure that a candidate possesses adequate knowledge of the language in which education is imparted.

The Law of 26 June 1963 setting up an Ordre des Architectes obliges civil engineers graduating after that date to take a two years practical course before having the right to sign, in their capacity as architect, plans for technical work which are solely within their competence as graduate engineers. Graduates in civil engineering who have specialized in architecture are exempt from this requirement.

The above information calls for the following comments:

1 In the review part of this study the Belgian *ingénieur civil* was quoted as a reference example of scientific education leading to a career in 'conception'.
2. It should be noted that some institutions training *ingénieurs-techniciens* provide a course lasting three years, whereas with others it is four years, which inevitably raises problems.
3 The reader will note the difficulty encountered by the *ingénieur-technicien* who seeks to become an *ingénieur civil*, namely the requirement of three years' additional studies. This is due to the need to complete his basic theoretical education in order to be able to change from a 'liaison' career to a career in 'conception'.
4. The reader will also note the existence of a central examining body making it possible for self-educated persons to obtain a degree

Czechoslovakia

The primary and secondary education of those going in for technical careers usually comprises nine years elementary education followed by a four-year science course at a *Gymnasium* Special primary and secondary education also comprises nine years' elementary education, followed in this case by a four-year specialized technical course

Both these types of education give access to technical universities providing a four year course for engineers Refresher courses for former higher education students entitle students to a number of days or weeks of leave for the preparation of examinations, during these courses they are paid by the industry for which they work.

The qualification of engineer is reserved for former students of technical and agricultural universities who have completed the course at one of the sixteen universities and obtained a corresponding degree.

All technological education establishments come under one of the two ministries of education (one for the Czech countries, the other for Slovakia). All are financed by the State.

The appropriate Ministry of Education is responsible for education, establishes the principles and objectives of teaching and scientific activities and the general curriculum of education. Detailed curricula are approved by the rectors of technical universities, and their implementation is supervised by the State.

The requirements of industry are expressed by the appropriate ministries and transmitted to the Czech or Slovak Ministry of Education

Architects graduate from the same technical universities as engineers. The above information calls for the following comments.

1. Technical universities provide a four-year course at university level for those who have completed thirteen years' primary and secondary education. Engineers graduating from these institutions therefore meet the requirements of category C (conception).

2. Graduates from specialized technical schools have successfully completed a four-year technical course, after nine years' elementary education, i.e. in all thirteen years' education, including four years of technical subjects. They therefore fully meet the standards for category E (execution).

3. This binary pattern, which does not include category L (liaison), differs from the ternary pattern to be found in the great majority of the other FEANI countries (see the monograph on Italy).

Denmark

The system of general education in Denmark comprises primary education (*hovedskole*) lasting seven years in all, the last two years of which are divided into two streams. the *boglig linie* leading on to a more classical type of education, and the *almen linie* leading on to a more modern type of education.

After the two-years of *boglig linie* (completion of primary education) and two years of *realafdeling* (the beginning of secondary education) pupils may go on to a further three years of secondary education in a *gymnasium* leading up to the *studentereksamen* (entrance examination for higher education) At this stage (i.e after twelve years primary and secondary education), they have a choice of two higher engineering schools. the Danmarks Tekniske Højskole (DtH) (Technical University of Denmark) where they take a five- to five-and-a-half-year course leading to the qualification of civil engineer (*civilingeniør*), or the Danmarks Ingeniørakademi (DIA) (Danish Engineering Academy) where they take a three-and-a-half to four year course leading to the qualification of academic engineer (*akademiingeniør*).

As regards professional technologists in other categories, after the two years of *almen linie* (completion of primary education) they take a two-year technical secondary course (*teknisk linie*) followed by *either* one year of theoretical education and three years of practical training *or* four years' part-

-time theoretical and practical education leading to the diploma of *tekniker* (after thirteen years' primary and technical education).

A *tekniker* who continues to study for a further three years at a *teknikum* obtains the diploma of *teknikumingeniør*.

Education at the Danmarks Tekniske Højskole comprises a five-year course for civil engineering or five and a half years for electrical, chemical and mechanical engineering It consists, in chronological order, of. a compulsory common core of mathematics, chemistry and physics, groups of compulsory courses in optional subjects, groups of non-compulsory courses in optional subjects.

The course at the Danmarks Ingeniørakademi does not allow of any freedom of choice for the first two years, and, for the remaining years, the choice of optional subjects is much more restricted than at the Danmarks Tekniske Højskole.

Six months to one year of practical training in industry is provided for students at the Danmarks Tekniske Højskole and the Danmarks Ingeniørakademi.

As regards continuing education, in 1971 the two professional associations of Danish engineers provided more than 300 courses, amounting to 200,000 student hours, which were taken by 4,000 to 5,000 engineers. These courses were devoted to the updating of knowledge and reconversion, where necessary, to another field.

For further education, there are courses at the Danmarks Tekniske Højskole to a technical diploma and doctor's degree Advanced courses may also be taken at the School of Economics and the university.

The qualifications of *civilingeniør* (Danmarks Tekniske Højskole), *akademiingeniør* (Danmarks Ingeniørakademi) and *teknikumingeniør* are restricted to graduates of the corresponding school. This does not, however, constitute a legal restriction in regard to the practice of the engineering profession.

Both the Danmarks Tekniske Højskole and the Danmarks Ingeniørakademi come under the Ministry of Education, which approves the programme of examinations. Curricula, on the other hand, are drawn up by the technical university or by the school itself. These institutions are 100 per cent State-financed.

The requirements of industry as regards these two institutions are expressed by the examiners In addition, the Danmarks Ingeniørakademi has an advisory committee which is empowered to make changes in curricula and examinations, ten of the members of this committee represent industry.

The two Danish professional associations of engineers organize interdisciplimary courses in medical technology, town planning and economics, management, etc.

Finland

The pattern of general education in Finland is at present as follows.

After a first primary-school course, lasting four years, the pupil has a choice between *either* a junior secondary-school course, lasting five years, followed by a senior secondary-school course, lasting three years, *or* a

senior primary-school course, lasting four years, followed by two years at a vocational school.

This being so, the facilities for educating professional technologists in Finland are at the present time as follows.

For graduate engineers *either*, in the case of those who have completed the senior secondary-school course (i.e. after twelve years' primary and secondary education), a four-and-a-half-year course either at a university or in a technical faculty, followed by one year's additional practical training (six to nine months), *or*, in the case of those who hold a degree of 'engineer', a four-and-a-half-year course at a university or in a technical faculty, followed by one year's additional practical training (six to nine months). Only 6 per cent of 'graduate engineers' choose this particular form of education.

For 'engineers' In 30 per cent of cases, a four-year course in a technical college taken on completion of the senior secondary-school course (i.e. after twelve years' primary and secondary education) which has been followed by twelve months' practical training, in 60 per cent of cases, a four-year course in a technical college taken on completion of the junior secondary-school course (i.e. after nine years' primary and secondary education) which has been followed by sixteen months' practical training, in 10 per cent of cases, a four-year course in a technical college taken on leaving the vocational school (i.e. after ten years' primary and vocational education) and on completion of sixteen months' practical training and two years at a technical school.

In future, general education in Finland will comprise nine years' compulsory comprehensive education (replacing the existing four-year course of primary education and the five-year course of junior secondary education) and three years' secondary education (replacing the existing three-year senior secondary-school course).

This being so, in future educational facilities for professional technologists in Finland will be as follows.

For graduate engineers. *either* a four-and-a-half-year course at a university or in a technical faculty, followed by one year's additional practical training (six to nine months), taken on completion of compulsory comprehensive education and secondary education (i.e. after twelve years' primary and secondary education), *or* a four-and-a-half-year course at a university or in a technical faculty, followed by one year's additional training (six to nine months), taken on completion of the nine years of compulsory comprehensive education followed by two years at a vocational school, a period of practical training and supplementary education.

For 'engineers'. *either* a four-year course at a technical college, taken on completion of compulsory comprehensive education and secondary education (i.e. after twelve years' primary and secondary education), *or* a four-year course at a technical college, taken on completion of the nine years of compulsory comprehensive education, followed by two years at a

vocational school, a period of practical training and two years at a technical school, *or again*, a four-year course at a technical college, taken on completion of the nine years of compulsory comprehensive education, followed by additional education, a period of practical training and two years at a technical school.

Education for 'graduate engineers' is provided in the following faculties. mechanical engineering, wood and paper technology, mining and metallurgy, chemical engineering, electrical engineering and applied physics, civil engineering, land surveying, production techniques, architecture.

Basic subjects taught during the first two years include mathematics, physics, chemistry, social sciences and general technical subjects. Vocational subjects are taught during the last two years, after which six months are allowed for preparation of a project.

A supplementary six to nine months' practical training period is optional, but confers additional credit points for the degree.

The total number of credit points required for the degree of graduate engineer is 160. Each credit point equals forty hours of work (compulsory or optional basic subjects, and vocational courses in the special subject chosen and related subjects).

Training for engineers is provided in the following branches. mechanical engineering, electrical engineering, civil engineering and the timber industry, chemical engineering, paper manufacture, production techniques, data techniques, data processing.

The basic subjects taught during the first two years include elementary mathematics, mathematics, physics, chemistry, the two national languages (Finnish and Swedish) and one foreign language. The general vocational subjects, taught during the first two or three years, include technical drawing, strength of materials, mechanical engineering, electrical engineering, the technology of raw materials, etc. Special vocational subjects are taught during the last two years, and the last year includes a general grounding in production, economics, etc.

A compulsory period of practical training, lasting twelve to sixteen months as the case may be, is taken partly before the technical-college course and partly during the summer vacation (which lasts four months).

The usual duration of the course (four years) is reduced to three for holders of the secondary school leaving certificate (twelve years primary and secondary education).

Technical colleges hold State-aided refresher courses for engineers. Those seeking to qualify for another special branch must take a course in the new special subject together with twelve to sixteen months' practical training therein.

The ministry responsible for the universities and technical colleges is the Ministry of Education, the National Board of Vocational Education, which forms part of this ministry, has a special section for technical education, which has particular responsibility for the administration of technical colleges.

University syllabuses are drawn up by the Teachers' Council and supervised by the Ministry of Education.

The curricula of technical colleges are approved by the National Board of Vocational Education. Some of these colleges (four out of six) are communal or private, but they are also supervised by the board and are partly State-aided.

The requirements of industry are expressed both centrally and locally. At the central level, industry is represented on the Council for Higher Education in Technology and Commerce, an advisory body of the Ministry of Education and on the Vocational Education Council, an advisory body of the National Board of Vocational Education for technical colleges coming under the board's Technical Education Section.

At the local level, industry is represented on the university councils and on the advisory councils of State technical colleges, whose members are chosen by the National Board of Vocational Education from among representatives of local industry.

Finland has concluded general agreements (not limited only to technical education) with the following countries:

For exchanges of students. the Scandinavian countries, Bulgaria, Czechoslovakia, France, the German Democratic Republic, Hungary, Poland, Romania and the U.S.S.R.

For exchanges of trainees. Austria, Belgium, France, Italy and Switzerland.

Semi-official agreements have been concluded by the Finnish Ministry of Labour with Canada, the Federal Republic of Germany, the United Kingdom and the United States of America.

As regards the relationship between the engineering and architectural professions, the situation is as follows:

For the universities architects graduating from faculties of architecture specialize in the design of buildings and regional planning. Graduate engineers specialize in. (a) the practical execution of projects, strength of materials, the supervision of construction, and the building of roads and bridges—in the case of those graduating from civil engineering faculties, *or* (b) heating, plumbing and ventilation—in the case of those graduating from mechanical engineering faculties.

For technical colleges. architects and engineers are educated in the civil engineering departments. Architects specialize in the planning of buildings and town planning, whereas engineers specialize in actual construction work. Moreover, 50 per cent of graduate engineers are employed in industrial administration and planning.

The above information calls for the following comments.

1 The graduate engineer belongs to the conception category, whereas the engineer meets the criteria for the liaison category, at a comparatively high level. It may seem surprising at first sight that the entrance level and duration of the courses for the two types of education differ only very slightly. The main difference lies in the career bias. The education of the Finnish engineer has been quoted for reference as an example of a liaison engineer.

2. The reader will note the many channels giving access to post-secondary education for engineers.

3. It will also be noted that an engineer seeking to become a graduate engineer is obliged to repeat the post-secondary part of the complete graduate course, due to the different career bias between the two types of education.

France

For those choosing a technical career, secondary education in France offers the following alternatives.

First, a scientific *baccalauréat* (secondary-school leaving certificate), obtained after seven years' scientific secondary education at a CES (*collège d enseignement secondaire*) with special emphasis on mathematics, physics and chemistry, the level of education in each subject varying according to the different sections. This may be followed by two years' preparatory studies for the competitive entrance examination to an engineering school, corresponding to the level of knowledge of a two-year course at a university, and divided into a first year of *mathématiques supérieures* and a second year of *mathématiques spéciales*.

Second, a technical *baccalauréat*, obtained after seven years' secondary education of a less scientific, more practical nature at a technical *lycée* (including, in particular, workshop practice).

Third, a scientific and technical *baccalauréat*, at the same level as the two preceding ones, but specially intended to qualify for admission to the preparatory courses for certain engineering schools, for example the *écoles nationales des ingénieurs des arts et métiers*.

Finally, it should be noted that there still exists another type of preparation, older than the technical *baccalauréat*, which is roughly equivalent though still more specialized, and leads to the *brevet de technicien* (BT).

A degree is shortly to be introduced which will confer equivalence on technical and scientific *baccalauréats* for access to post secondary education.

Schools which educate graduate engineers generally require the two-year preparatory course after the *baccalauréat* (*mathématiques supérieures* and *mathématiques spéciales*) plus a three-year course at the engineering school itself, comprising or supplemented by practical training periods. In any case, an engineer usually graduates on completion of five years' study after the *baccalauréat*.

To go into greater detail, admission to one of the 147 schools which educate graduate engineers is as follows:

- *For students from university faculties, without an open competitive entrance examination* for holders of the *diplôme universitaire d études scientifiques* (DUES) at the first-/second-year level, or the first-year certificate (forty-nine schools), on presentation of the DUES (fifty three schools),
- by special competitive examination reserved for holders of the DUES (twenty-three schools), for those holding a *licence* (first university degree) in science or two master s certificates (seventeen schools), for those with a master's degree (seventy-five schools).

For those who come from the classes préparatoires *(equivalent to first two years of university) with an open competitive entrance examination.* at the level of *mathématiques supérieures*, i.e. one year after the scientific *baccalauréat* (fifteen schools only), on completion of the *mathématiques spéciales* curriculum, i.e. two years after the scientific *baccalauréat*, *mathématiques spéciales A* (fifty-eight schools), *mathématiques spéciales A'* (seventeen schools), *mathématiques spéciales B* (forty-eight schools), *mathématiques spéciales C* (sixteen schools), with a special competitive examination reserved to students coming from technical schools (thirty schools).

For students from technical schools, without an open competitive entrance examination. for those holding the *brevet de technicien supérieur* (BTS) (nineteen schools), for those in *classes préparatoires* (preparatory classes) for the *écoles nationales des arts et métiers* (candidates for these particular schools), for holders of a *diplôme d'études supérieures techniques* (DEST) under the higher social advancement programme (the DEST is awarded in particular by the Conservatoire National des Arts et Métiers (CNAM)).[1]

The 143 French schools usually provide a five-year course for graduate engineers, including the one- or two-year preparatory course. They also include a number of specialized schools which offer shorter courses (two years instead of three) to graduate engineers.

The education of senior technicians comprises *either*, after the technical *baccalauréat*, two years at an *institut universitaire de technologie* (IUT) which awards the *diplôme universitaire de technologie* (DUT), *or*, after the technical *baccalauréat*, two years at a State or private school (sections forming part of technical *lycées*) the certificate awarded in this case is the *brevet de technicien supérieur* (BTS), *or* the *promotion supérieure du travail* (higher social advancement) programme, leading to the *diplôme d'études supérieures techniques* (DEST).[2]

Senior technicians holding the DUT are educated in the following nine special fields. applied biology (agronomy, food industries, dietetics, biological and biochemical analyses, environmental hygiene), chemistry, chemical engineering, civil engineering (building and public works), electrical engineering (electrotechnology, electronics, automatic control), mechanical engineering (construction and production), heat engineering (heat machines, heat generators, refrigerating machines, air conditioning), physical measurements (physico-chemical and physical techniques and measurements), hygiene and safety (accident prevention and public safety, hygiene and safety in industry).

Senior technicians holding the BTS have a choice of some forty special subjects, divided into the following six main groups. civil engineering,

1 The DEST should not be confused with the CNAM engineering diploma which is awarded to a very small proportion of the tens of thousands of students following the courses at the CNAM in Paris or its many affiliated centres in the provinces after years of attendance and laboratory work, numerous examinations, a general examination and the defence of a thesis

2 The DEST awarded under the *promotion supérieure du travail* programme is roughly equivalent to the DUT and the BTS For example at the Conservatoire National des Arts et Métiers the DEST is awarded after the candidate has obtained twelve annual certificates in courses or laboratory work of his own choice A feature of this type of education is that there are no rigid entrance requirements, the final judgement being based on proof of the skills acquired

metallurgy, mechanical engineering, electrical engineering, textile industries, chemical and physico-chemical industries, various vocational activities, applied arts.

As already noted, technicians are trained *either* by taking the *brevet de technicien* (BT) *or* in technical *lycées* (the technical *baccalauréat*) *or* in *lycées* of the same level (the scientific and technical *baccalauréat*).

The Law of 16 July 1971 on vocational education stipulates that firms must devote 0.8 per cent of the payroll (2 per cent as from 1976) to staff education A wage-earner may apply for study leave under certain conditions, for example in a State-approved school and for a maximum of 100 hours a year, which do not count as part of annual paid leave.

This law also provides for an educational fund to enable an employee, as part of his paid continuing education and provided that he has completed at least three years' practical experience and been with the firm for at least two years, to be paid during his studies. Article 10 of the same law also makes provision, with possible financial assistance from the State, for. (a) refresher courses (updating of knowledge), (b) conversion and adaptation courses (reconversion), (c) educational courses for professional advancement and preliminary education courses for young people (further education).

The engineering degree obtained by engineers graduating from schools which award a degree recognized by the proposal of the Commission des Titres d'Ingénieur is protected by the Law of 10 July 1934, but the title of *ingénieur* as such is not protected. In the case of the self-educated it frequently corresponds to a post held within the firm.

The qualifications of other professional technologists are not protected by law, but it has become the established practice to adopt the same attitude for these categories as for graduate engineers, namely. (a) anyone is entitled to call himself a *technicien supérieur* or *technicien*, (b) no one, however, may call himself a *technicien supérieur breveté* or a *diplômé universitaire de technologie* or a *technicien breveté* without holding the corresponding diploma (BTS, DUT and BT respectively).

Higher or secondary technical schools are subdivided into State schools, private schools recognized by the State (generally subsidized) and private schools.

Diplomas are always awarded or recognized by the State in the case of the first two, and sometimes recognized by the State in the case of the third.

The first two categories generally come under the Ministry of Education, but a few are under the ministries of industrial and scientific development, defence or agriculture.

Private schools are entirely independent, private schools recognized by the State, and State schools, are partly independent.

In the case of State schools or private schools recognized by the State, the State lays down curricula, supervises their implementation and exercises general supervision through the appropriate ministry.

Continuing education is organized independently of the State. There is supervision by the State only when its approval is necessary (in the case of leave for continuing education) or where continuing education is State-aided.

As regards the education of graduate engineers, the requirements of industry are communicated to the heads of schools, who transmit them to the Conseils de Perfectionnement (councils for academic improvement). Where these requirements are extensive, they may be addressed directly to the appropriate ministry.

As regards the IUTs more particularly, panels take part in the choice of curricula, the siting of the establishments, etc.

These panels, comprising employers' representatives and representatives of manual and office workers' unions, but with a majority of civil servants from the Ministry of Education, meet at three different levels. at the national level, for each special branch, at the level of the region in which the school concerned is situated, at the level of the school itself (its governing board).

Industry is represented on the boards of examiners for the *brevet de technicien* (BT), the technical *baccalauréat*, the *brevet de technicien supérieur* (BTS) and the *diplôme universitaire de technologie* (DUT).

A rule—which is not always adhered to in practice—is that one-third of the teachers of IUTs should be appointed from among practising engineers and professional staff.

Some categories of BTS and DUT involve compulsory practical training periods. With the exception of the very large firms, French industry is somewhat reluctant to take trainees. International exchanges of trainees take place through the International Association for Exchange of Students in Technical Experience (IASTE).

The Law of 16 July 1971 on vocational education, and particularly its provisions for an educational fund permitting the best possible combination of full-time with part-time study, provides the opportunity. (a) for holders of the *certificat d'aptitude professionnelle* (CAP) or the *brevet élémentaire professionnel* (BEP)—i.e. technicians at a fairly low level, below the execution category as defined in the present study—to obtain the *brevet de technicien* (BT) or the technical *baccalauréat*, (b) for holders of the BT or the technical *baccalauréat*, to pass the *brevet de technicien supérieur* (BTS) or the *diplôme universitaire de technologie* (DUT), (c) for holders of the BTS or DUT either first to pass the DUES, qualifying for entry to the second university cycle, and then to take a master's degree, or even—with the new legislation—to obtain an engineering degree. (It should be noted that the possibility has long existed for the self-educated to acquire the legal qualification of *ingénieur diplômé par l'Etat* (DPE) by going before a board of examiners).

France has signed agreements with French-speaking African States, Latin American States and certain other States for practical training periods held on behalf of the Ministry of Industrial and Scientific Development and the Ministry of Economics and Finance by the Agence pour la Coopération Technique, Industrielle et Economique (ACTIM), which forms part of the latter ministry. This agency also runs practical training periods organized by UNIDO for professional staff having held positions of responsibility.

Only members of the Ordre des Architectes (the professional association of architects) are entitled to call themselves architects in France, but there is no professional association of engineers.

Educational programmes for architects are currently being reorganized to provide education of the kind given in engineering schools.

Consulting engineers, with the full agreement of the ministries concerned, refuse to entrust the supervision of work to architects alone An agreement on the practice of their profession was signed in 1957 between the Ordre des Architectes and the Chambre des Ingénieurs-Conseils de France.

As regards senior technicians and technicians the following types of education are provided by the Ministry of Education. (a) the BTS in building or public works, and the DUT in civil engineering, (b) the BT and the technical *baccalauréat* in the various trades.

The work performed by senior technicians (BTS or DUT) corresponds to the posts of work supervisors, professional staff and middle-level survey staff (the PERT method, etc) or costing staff. Some are supervisors and contractors.

Several types of agricultural BTS exist in France, for which education comes under the Ministry of Agriculture, but their pattern (a two-year course) is the same as that of the BTS awarded by the Ministry of Education. The same applies to the agricultural BT.

On the other hand, the DUT in applied biology, which includes dairy farming as an optional subject, is awarded by some IUTs coming directly under the Ministry of Education.

France also has a BTS for geology, awarded by the Ministry of Education. Many of its holders have been employed in oil prospection in Algeria.

Opportunities for management studies are available to French engineers through the post-graduate courses of the Institut d'Administration des Entreprises (IAE), the Paris Chamber of Commerce, etc.

Socio-economic surveys conducted by the Fédération des Associations et des Sociétés Françaises d'Ingénieurs Diplômés (FASFID) in 1967 and 1971 show that, after the age of 40, roughly one-half of graduate engineers perform functions which go beyond a purely technical context, such as those of company directors (generally the pinnacle of their career), careers in commerce, banking, insurance, etc.

The rather complex situation in France calls for the following comments.

1 The complexity of this situation provides an example of the results of reforms introduced at different times, while certain traditions are allowed to survive

2 It is interesting to note the concern with higher social advancement studies, an example of which is the DEST. Noteworthy, too, is the recent experiment in continuing education, unprecedented in Europe (the Law of 16 July 1971 on vocational education).

3 The comments with regard to graduate engineers call for some carefully considered distinctions:

The entrance requirement is, as it should be, the completion of an advanced secondary-school course.

The duration of training, including the university-level preparatory classes (i e *mathématiques supérieures* and *mathématiques spéciales*) is

generally that laid down in the criteria adopted for the conception career (four years).

However, education in certain schools lays great emphasis on theory, their graduates are amply qualified as theory goes, but not enough in practice. They are scientists rather than engineers, so that many of them continue their education in a specialized school. These professional technologists undoubtedly rank in the highest class of the conception category.

Among the other schools, a distinction should be drawn between those of a university nature and those whose bias is towards practical and specialized fields.

Although the Law of 10 July 1934 prohibits any legal discrimination between graduates from the 143 schools, it may be assumed that some of these graduate engineers belong in fact to the conception category, whereas others fit into the liaison category. It would take a study of individual cases to settle the substance of this question, since the answer may vary not only from one school to another but also at different times for the same school.

4 Among liaison engineers a distinction can probably be drawn between.

(a) The holder of the DUT, who, on completion of full secondary technical education, takes a two-year higher technical course. He appears to fit into the liaison category, though not exactly complying with the qualification criteria.

(b) The holder of the BTS, who is roughly in the same situation.

(c) The holder of the DEST.

As has already been said, higher social advancement studies cannot by definition be subject to rigid rules as regards either entrance requirements or their duration. Judgement can therefore be passed only on the results of the skills finally acquired, so that the inclusion of the holder of the DEST in the liaison category is by assimilation.

5 The technical *baccalauréat* covers thirteen years' primary and secondary education, of a technical nature during the secondary-school course. It may be concluded that it leads to a career in execution, though not exactly complying with the criteria for this category.

The same applies to the scientific and technical *baccalauréat* and the BT (*brevet de technicien*).

Federal Republic of Germany

After four years' primary education at the *Volksschule*, the German pupil has a choice between two types of secondary education. (a) a more traditional type *Gymnasium*, leading, on completion of nine years secondary education, to the *Abitur* (giving access to university education), (b) a more modern, practical type *Realschule*, leading on completion of six years secondary education to the *Mittlere Reife* (certificate of partial secondary education).

It should be noted, first, that the *Mittlere Reife* can also be obtained at a *Gymnasium* on completion of six instead of nine years' secondary education.

Secondly, it should be noted that a new type of vocational secondary education has recently been introduced. This is the *Fachoberschule* (higher vocational school) leading, on completion of two years additional education after the *Mittlere Reife*, to the *Fachoberschulreife* (a kind of technical *Abitur*, obtained on completion of twelve instead of thirteen years' primary and secondary education).

Diplomingenieure are educated at *Technische Hochschulen* (technical universities), to which they are admitted with the *Abitur*, after having completed six months' basic practical training (*Grundpraktikum*). Here they spend five to six years, including a further six-month period of professional practical training (*Fachpraktikum*) and a terminal project leading to the qualification of *Diplomingenieur*.

Ingenieure grad (graduiert) used to be educated at *Ingenieurschulen* (engineering schools), to which they were admitted with the *Mittlere Reife* i.e. after only ten years' primary and secondary education followed by two years' practical training. Here they completed a three-year technical course leading to the qualification *Ingenieur grad. (graduiert)*.

Ingenieurschulen were recently replaced by *Fachhochschulen* providing education for a higher qualification. The entrance requirement is the *Fachoberschulreife* (i.e. completion of twelve years' primary and secondary education) and the duration of the course is three or four years, including one year's practical training, depending on the individual *Land*.

A trend seems to be emerging at present to group together, where possible, the *Technische Hochschulen* and the *Fachhochschulen* into comprehensive technical universities (*Gesamthochschulen*), which would provide courses on the following broad lines:

1. The same entrance requirements (twelve years' primary and secondary education), whatever the type of course taken towards the end of secondary education.

2. A common core of basic subjects, lasting a maximum of two years.

3. Diversification of courses depending on the career envisaged.

4. A practical training period of at least three months at the beginning of the technical course.

5 A second practical training period in a professional subject, lasting from three to twelve months, taken during the university course and depending on the career envisaged.

It is not yet clear whether the various types of courses will qualify for a single or separate diplomas.

The qualification of engineer is at present somewhat ill-defined, on account of the very fluid situation existing with respect to the structure of schools.

Each of the eleven *Lander* brought out a law protecting the use of the qualification of engineer, which was reserved for graduates from the *Tech-*

nishe Hochschulen, the former *Ingenieurschulen* and the new *Fachhochschulen*, as well as a number of self-educated persons who had called themselves engineers before the law came into force.

For the past two years the right to call oneself an engineer, for those who have newly entered the profession, has been reserved solely for graduates from *Technische Hochschulen* and *Fachhochschulen*.

The universities, the technical universities (*Technische Hochschulen*) and *Fachhochschulen* come within the educational and cultural definition of the *Land* in which they are situated, and are subject to its legislation. They are, however, autonomous as regards their organization, their curricula, the appointment of their rector (changed at regular intervals) and chancellor, and the setting up of administrative and scientific committees.

A federal commission for the education and training of engineers receives the requirements stated by industry and passes them on to the ministries of education and cultural affairs of the *Lander* and their federal conference.

In some *Lander*, for example North-Rhine-Westphalia, there are statutory corporations of architects, with which architects must register in order to be able to practise their profession.

The following comments may be made on this somewhat complex situation.

1. *Fachoberschulen* correspond roughly to the type of education laid down for the 'execution' category, but it seems that the level is below that of the European Economic Community definition (two years' technical education instead of three).

2 The qualification of *Diplomingenieur* corresponds to the choice of a career in the 'conception' category. Of particular note is the relatively lengthy duration of the education and the emphasis placed on periods of practical professional training.

3 The former *Ingenieurschulen* corresponded to the choice of a career in the 'liaison' category.

4. The same seems to apply in the case of the *Fachhochschulen*, but it will be noted that these are tending to raise the entrance level and to diversify the duration of the course (three or four years). Diversification has inevitably given rise to discussions which have not yet resulted in full clarification.

5 The new legislation being prepared with regard to *Gesamthochschulen* (not yet approved) is likely to cause some perplexity. As regards particularly the *Technische Hochschulen*, it will be noted that the entrance level has been lowered, without however involving any change in the type of education, i.e. 'conception' engineering, at least to the extent that engineering education remains at university level, which seems in fact to be the case.

As regards more particularly *Fachhochschulen*, it will be noted that, on the contrary, entrance requirements are at a relatively high level (the same as for the *Technische Hochschulen*).

Noteworthy features of the two types of education are. (a) a common basic core, though its duration is not clearly defined (maximum duration of two

years), (b) diversified courses depending on the choice of career, though neither their duration nor their type is known exactly.

Under present conditions it is difficult to know whether students from these establishments who have received a more practical education will continue to go in for a 'liaison' career or will tend rather towards 'conception'. Some people hold the view that, should they be considered as educated for 'conception', the result would be a gap in the number of those educated for 'liaison', and that in the end 'liaison' would be performed either by under-employed 'conception' personnel or by overworked 'execution' personnel, ill-prepared in both cases for their tasks.

It would be premature as yet to express a final opinion on the question, and the above comments are given solely for information purposes, while showing at the same time the difficulty of solving this kind of problem in a constantly changing situation.

Greece

After six years at the *dimotikon scholeion* (primary school), the Greek pupil has a choice of three streams of secondary or technical education. *either* traditional secondary education (at a *gumnasion*), which leads after a six-year course to the *apolytirion* (secondary-school leaving certificate giving access to university education), (It is the opinion of the Technical Chamber of Greece itself that the level of this certificate is lower than that of the French *baccalauréat*, the German *Abitur* or the Italian *maturità*), *or* elementary technical education (*katoterai technikai scholai*), which leads after a three-year course to the *technitis* (elementary technical certificate), *or again*, a vocational training school (*scholeion mathitias*) which leads after a four-year course to the same elementary technical certificate.

Engineers are educated in technical faculties (*polytechneion*) to which they are admitted with the *apolytirion*, supplemented by an additional course in mathematics, physics and chemistry (given in special schools) and on passing an entrance examination. They spend five years at the *polytechneion* before obtaining their engineering qualification.

Technicians are educated in middle-level technical schools (*meseai technikai scholai*), to which they are admitted. *either* after three years' secondary education at a *gumnasion* (i e. after nine years' primary and secondary education). *or* after three years' elementary technical education (*katoterai technikai scholai*) (i.e. after nine years' primary and technical education leading to the elementary technical certificate (*technitis*)), *or* after four years' vocational training in a *scholeion mathitias* (i.e. after ten years' primary and vocational education and training, also leading to the *technitis*). They spend three years at this middle-level technical school, from which they graduate with the qualification of *technitikos voithos* (technical assistant)

Senior technicians are educated in *scholai ypomichanikai* (schools for assistant engineers), to which they are admitted. *either* after a four-year secondary course at a *gumnasion* (i e after ten years primary and secondary

education), *or* with the qualification of technical assistant (*technitikos voithos*).

Here they take a four-year course, graduating with the qualification of *ypomichanikos* (assistant engineer). This qualification in turn gives unconditional access to a *polytechneion* (technical faculty), which provides a five-year educational course for engineers.

The qualification of engineer is protected by law and reserved solely for graduates of the technical universities, technical faculties (*polytechneion*) and universities or the equivalent foreign universities or engineering schools.

An engineer must register with the Technical Chamber of Greece (founded in 1923) in order to be entitled to practise the profession.

To qualify as an engineer, a candidate must. (a) pass all the examinations of a Greek technical university or faculty, or (b) show proof of education received abroad, and pass a general professional examination.

All technical universities or faculties come under the Ministry of Culture and Education. They are independently administered, but are supervised by the State. Curricula are established by the State in collaboration with each school, and their implementation is supervised by the State.

Fees are negligible (education is provided almost free of charge) and all schools are State-subsidised.

In Greece, only graduates from technical universities or faculties are recognized as architects, in the same way as engineers graduating from the other faculties of these same schools.

Where important structural calculations have to be made, the architect must work in conjunction with a graduate civil engineer, who is legally responsible for the safety of the new construction. The engineer receives 60 per cent of the fee for the calculations, leaving 40 per cent to the architect.

The information above calls for the following comments.

1. The engineer meets the criteria for the conception category (C).

2 The assisant engineer (*ypomichanikos*) belongs to the liaison category (L),

3 The technical assistant (*technitikos voithos*) is roughly in the execution category (E), though his qualifications fall a little short, i.e., twelve years' education (instead of thirteen), followed by a three-year technical course.

4 The *technitis*, included only in order that the list may be complete, belongs to a lower-level cate[illegible] which falls outside the framework of the present study.

Ireland

Secondary education, completed around the age of 18, leads to the leaving certificate examination or matriculation.

The latter, with in addition a special entrance examination in mathematics for those who have not demonstrated adequate capacity in that subject, gives admission to one of the four Irish universities, which offer a four-year course for the bachelor's degree in engineering.

Although the system differs slightly according to the university, it is broadly similar to that of the United Kingdom.

During the first year at most of the universities students take courses which are more or less common to all groups, whatever their choice of special subject. In the second year they begin to specialize in one of the following fields. civil engineering, mechanical engineering, electrical engineering, chemical engineering, agriculture.

The total number of engineering students in 1971/72 in each of the four universities was as follows. University College, Dublin, 622, University College, Cork, 359, University College, Galway, 175, Trinity College, Dublin, 193. This gives a total of 1,349 students.

In addition to universities which award a bachelor's degree, technical colleges provide vocational education for other categories. They also recruit students at the age of 18, but on the basis of a preliminary examination as specified by professional institutions. Students take a course which lasts at least four years, some of them full-time, some part-time.

The vast majority of Irish engineers graduate from a university, although a few obtain their engineering qualification by passing the examination of the Institution of Engineers of Ireland (IEI).

The qualification of chartered engineer, protected by law, is awarded by the IEI to those who fulfil the following conditions. (a) a pass in an IEI examination, (b) minimum age 25, (c) corporate membership of the IEI, (d) inscription on the roll of the IEI for those who have obtained the title of chartered engineer from another recognized body, which is itself affiliated to the IEI.

Universities have academic freedom, but are State-aided and maintain contact with the Department of Education. Technical colleges are generally more dependent on local authorities, though they keep their academic freedom.

The governmental Higher Education Authority examines matters of policy as regards engineering education, without interfering with academic freedom. A National Council of Education Awards rationalizes the award of qualifications.

The information received makes it difficult to comment on the situation in Ireland, which is, however, fairly similar to that existing in the United Kingdom.

Italy[1]

Italian education comprises, for all pupils, five years at a *scuola elementare* (between the ages of 6 and 11) followed by three years at a *scuola media*.

From this point onwards technical education may be obtained at an *istituto tecnico* offering a five-year course.

After the eight years spent successively at the *scuola elementare* and the *scuola media*, the secondary-school pupil has the choice of at least two streams. *either* two years at a *ginnasio*, followed by three years at a *liceo*

1 This information is communicated without any guarantee that it is up to date, since the replies to the questionnaire were incomplete

classico, leading to the traditional secondary-school leaving certificate (*maturità classica*), or five years at a *liceo scientifico*, leading to the scientific secondary-school leaving certificate (*maturità scientifica*).

At present, these two types of secondary education—and possibly others on which we have no information—give access to the universities and in particular to their technical faculties.

A five-year course in an engineering faculty leads to the *laurea* (engineering diploma) with the qualification of *dottore in ingegneria* (Dott.Ing.).

This diploma does not give its holder any entitlement to call himself an engineer. The title of *ingegnere* is conferred by the Consiglio Nazionale degli Ingegneri, of the Ministry of Justice, to Italian citizens who hold the *laurea* (i.e. the qualification of *dottore in ingegneria*). In Italy only *ingegneri* are entitled to practise the engineering profession, individual temporary arrangements may, however, be made for foreign engineers desiring to practise in Italy.

Each province has an Ordine degli Ingegnere, or professional association of engineers, there is no national professional order of engineers in Italy.

Higher technical schools are directly responsible to the State, and come under the Ministry of Education.

Some schools are the special responsibility of regions, provinces or communes.

Universities have academic independence, but financially they are almost entirely dependent on the public authorities.

University curricula are not laid down by the ministry, but theoretically it supervises their application. In any case, the public authorities exercise general supervision over the operation of the universities.

The relationship between industry and higher technical education is very limited. Industry hardly participates at all in the education of the engineer before he obtains his *laurea* (diploma).

Present legislation enables all qualified engineers to engage in the same activities as architects, except for the restoration of historical monuments, a field which is reserved solely for architects (*architetti*).

The existing situation in Italy may be commented on as follows.

1. The qualification of *dottore in ingegneria* meets the criteria for the conception category.

2. It is worth noting that in Italy there is a special provision which stipulates that the practice of the engineering profession is open only to those of Italian nationality.

3. The situation is not very clear as regards liaison and execution staff.

A graduate from an *istituto tecnico* has successfully completed five years at a *scuola elementare*, three years at a *scuola media*, and five years at an *istituto*. He would therefore seem to be qualified for the career of execution technician.

Under these circumstances, the Italian system, subject to the reservation expressed at the beginning of this monograph, seems to be of a dual type, which is very rare in Europe (in this connexion, see the monograph on Czechoslovakia).

Luxembourg

In Luxembourg there is no university education for engineers, they are educated abroad.

The technician engineer educated in the Grand Duchy proceeds, after six years' primary and six years' secondary education, to a course of at least two years in a higher technical school, supplemented by appropriate practical training periods.

Luxembourg technicians, after obtaining the lower vocational education certificate (*certificat d'aptitude professionnelle*), follow *either* evening classes, i.e. part time education, lasting several years, *or* a two-year full-time course.

Technician engineers and technicians are educated in separate departments of institutes of technical education.

The departments for technician engineers devote 18 per cent of their time-table to general education, 72 per cent to scientific subjects (mathematics, physics, mechanics, electricity, graphic statics) and only 10 per cent to practical training.

There are plans to raise, without changing its nature, the general level of education for the technician engineer.

The departments for technicians also devote 18 per cent of their time-table to general education, but 60 per cent to practical training and only 22 per cent to scientific subjects (algebra, analytical and descriptive geometry, trigonometry, differential and integral calculus, physics, chemistry, mechanics).

Qualifications are regulated by the Law of 17 June 1963. There is a law providing for access to the profession of independent engineer (consulting engineer).

Technical schools come under the authority of the Luxembourg Ministry of Education, on which they are entirely dependent as regards curricula and budgetary resources.

The teachers themselves are alone responsible for seeing that the curricula are applied.

Curricula and the distribution of subjects are approved by the Ministry of Education.

Industrial firms give their professional staff an opportunity to attend seminars held at regular intervals by the Luxembourg Office pour l'Accroissement de la Productivité and, in economic subjects, by the Université Internationale des Sciences Comparées. They also give engineers in their employ the opportunity to improve their skills abroad in institutions such as the Belgian Fondation Industrie-Université, the French Cégos, etc. Some Luxembourg firms also defray educational expenses for their future foremen or technicians at special schools abroad, such as the École de Maîtrise et d'Ouvriers Métallurgistes (EMOM) et Longwy (France), etc. Industrial firms of a certain size hold regular training courses within the firm for their professional staff, to which they invite instructors in special subjects from neighbouring countries.

Technicians may, after passing an entrance examination, attend schools which educate technician engineers.

Netherlands

In the Netherlands the secondary-school course, lasting six years, is normally completed around the age of 18. For those who have chosen to go in for a technical career, it consists primarily of mathematics, chemistry, physics and foreign languages.

Engineers ('Ir.') take a five-year course at a university on completion of the full secondary-school course.

Senior technicians ('Ing.') take a four-year course at an HTS (*hogere technische school*) on completion of a shorter secondary-school course ending at the age of 17 (instead of 18).

Technicians take a four-year course at a UTS (*uitgebreide technische school*) on completion of an even shorter secondary-school course ending at the age of 15.

At an HTS, 50 per cent of the student's time is devoted to general and scientific education (mathematics, physics, chemistry, mechanics) and 50 per cent to practical training. A similar time-table is in force at the UTSs.

Practical training in industry during the course lasts from sixteen to twenty-four weeks at technical universities, and from sixteen to thirty-nine weeks at HTSs.

International firms such as Philips, Unilever, etc., hold refresher courses for their staff.

The engineering profession is not subject to regulations in the Netherlands. At present, the only qualification protected is the degree of graduate engineer of a technical university (*technische hogeschool*): those holding it may precede their names with the abbreviation 'Ir.'.

In the near future, graduates from HTSs will have the right to add the abbreviation 'Ing.' after their names.

In the Netherlands higher technical education is divided into two types: (a) the *openbaar onderwijs*, comprising technical universities and HTSs, which are State or municipal foundations, administered and almost entirely financed by the State or municipal authorities, and (b) the *bijzonder onderwijs*, comprising technical universities and HTSs, which are founded, administered and managed by denominational or other private organizations. They are to a large extent financed from public funds.

The Ministry of Education and Science is responsible for both types of higher technical education.

The policy of a technical university is defined by its Academic Council, consisting at the most of forty members, and is implemented by its executive board, consisting at the most of five members. Each college of a technical university has its own executive board responsible for administration and teaching.

From the administrative point of view, HTSs are comparable to colleges of technical universities.

In technical universities the application of curricula is inspected by the Academic Council, while an inspector appointed by the ministry supervises HTSs. Curricula must be approved by the Ministry of Education and Science.

Liaison between higher technical schools and industry is catered for as follows: (a) frequently teachers have worked previously in industry, (b) the

majority of teachers continue to act in an advisory capacity in industry. (c) nearly half the teachers hold extra appointments, and continue to work at the same time in industry.

In HTSs, there are 72,000 full-time students, whereas 51,600 students take part-time courses.

Graduates from HTSs are admitted to technical universities.

A new law being prepared provides for the selection of students at technical universities and HTSs by means of pre-university examinations to be held at the end of a one- or two-year course of common subjects.

A treaty has been signed between the Netherlands and Belgium for the mutual recognition of examinations of technical faculties of Belgian universities and Netherlands technical universities.

A law is being prepared on the qualifications of architects. A register of architects exists, which is generally recognized, though enrolment is not compulsory. Architects graduating from a university are exempt from the entrance examination for enrolment on this register.

Norway

In Norway, secondary education for pupils intending to follow a technical career consists primarily of mathematics, physics, chemistry and languages (Norwegian, English, German, French). The full course ends with a final examination (*examen artium på reallinjen*).

After this examination, engineers take a four-and-a-half-year educational course at the Norwegian Institute of Technology, as follows. the first two years are devoted to mathematics, physics, chemistry and mechanics, the next two years are devoted to general technical subjects and subsidiary economic subjects, the last semester is devoted to a special subject and terminal work on a thesis.

The education for Norwegian senior technicians consists of. *either* a two-year higher technical course, on completion of full secondary education, *or* a three year higher technical course, after nine years' compulsory primary and secondary education.

In both cases, higher technical education is preceded by one year's practical training in industry.

The Norwegian Institute of Technology educates engineers in the following eight special subjects. architecture, mining and metallurgy, petroleum technology, civil engineering, electrical engineering, chemistry and chemical engineering, mechanical engineering, industrial physics.

Norwegian professional engineering associations organize many refresher courses Graduates from the Norwegian Institute of Technology have the opportunity of reconversion by studying for a technical degree (Ph.D.) in another branch.

Since 1949 the qualification of *sivilingeniør* has been protected by law, and reserved for graduates from the Norwegian Institute of Technology and Norwegians who have graduated from foreign schools or universities recognized by the public authorities.

As regards senior technicians, the *tekniskskoler* (technical secondary schools) have become *ingeniørskoler* (engineering colleges) and the qualification they confer has become that of *ingeniør*, though it is not protected by law.

The Norwegian Institute of Technology, which educates engineers at university level, is the former Norwegian Technical University at Trondheim. It now belongs to the University of Trondheim, and will probably in future become its technical faculty.

The institute comes directly under the authority of the State Department of Education, as do also the thirteen engineering colleges.

General curricula are drawn up by the public authorities and the details are worked out by the schools themselves. Curricula are not applied until they have been approved by the government, which carries out inspections from time to time by means of appointed committees.

Moreover, the public authorities exercise a general control over the education system through the budgetary process.

The Norwegian Institute of Technology keeps in close touch with industry through its Council for Education Improvement, on which industry is represented. Industry is also represented on *ad hoc* committees which are responsible for the long-term planning of the education of engineers.

For some types of technical education, practical training periods in industry are a compulsory complement of education. In addition, many of the problems studied by the students originate in industry.

Graduates from the engineering colleges are admitted to the second year at the Norwegian Institute of Technology provided they have taken a course in mathematics during the summer preceding their admission. Thirty per cent of the students of the institute come within this category.

Bilateral agreements have been concluded, (a) between the Norwegian Institute of Technology and the Swedish Royal Technical University at Stockholm, for the admission of Norwegian students to the aeronautics department, (b) for petroleum technology, between the Norwegian Institute of Technology and two foreign universities, one in the Federal Republic of Germany and the other in Austria.

During their professional careers many engineers rise to posts which are of a more administrative and interdisciplinary character. This is the case with many Norwegian heads of industry, who are engineers.

The information above calls for the following comments:

1 The *sivilingeniør* who has graduated from the Norwegian Institute of Technology meets the criteria of the conception category.

2. The senior technician or *ingeniør* graduating from a *tekniskskole* which has now become an engineering college (*ingeniørskole*), appears to come within the liaison category on account of the high level of his education, [illegible] notwithstanding the fact that it is somewhat short and that the entrance requirements for the *ingeniørskole* are not very exacting.

3 It is interesting to note the opportunity available to a senior technician or *ingeniør* to become a *sivilingeniør* without too much difficulty or loss of time.

Portugal[1]

In Portugal general education comprises, first, a lower level of compulsory education consisting of four years' primary education, followed by *either* two years' primary education which is a terminal course *or* a two-year preparatory common course at a secondary school, leading to the upper level which is optional.

On completion of the six-year compulsory education, the Portuguese pupil has a choice, at the upper optional level, between two types of courses. *either* a five-year course at a traditional secondary school, comprising three years' general and two years' additional education, *or* a five-year course in industrial technical education, comprising three years' training in industry and a two-year course qualifying for an industrial institute.

Admission to a university is normally on completion of the additional secondary-school course, i.e. after eleven years' primary and secondary education and after an entrance examination. Future engineers take a five-year course at the university, the syllabus for the last two years providing for at least one-third of the time to be devoted to work in a laboratory or workshop. This education is supplemented by a six-month practical training period in industry.

Admission to industrial institutes is through one of the following three channels. *either* completion of the general course at a secondary school, i.e. after nine years' primary and secondary education and after an entrance examination, *or* completion of the course qualifying for industrial institutes, i.e. after eleven years' primary and technical education and after an entrance examination, *or* completion of the additional course at a secondary school, i.e. after eleven years' primary and secondary education, and no entrance examination.

The duration of the course at industrial institutes is four years, at least one-third of the time being devoted to work in a laboratory or workshop. This course is followed by a six-month practical training period in industry a report on this period and an examination in vocational proficiency.

Students in their second year at an industrial institute may be admitted to the university on taking an entrance examination.

Industrial institutes have three departments. electro-mechanical engineering, civil engineering and mining, chemical engineering (laboratory and industry).

University education leads to the qualification of *engenheiro*, in order to practise the profession, its holders must belong to the Ordem dos Engenheiros, the professional association of engineers.

The course at industrial institutes leads to the qualification of *agente técnico de engenharia*, holders of this qualification join the Sindicato Nacional dos Engenheiros Auxiliares, Agentes Técnicos de Engenharia e Condutores.

The present situation in Portugal calls for the following comments.

1. After eleven years' primary and secondary education, the engineer takes a five-year course of study at the university, followed by a six-month

1 This information may not be entirely up to date, since it is based on incomplete replies to the questionnaire.

practical training period in industry. Although the duration of his primary and secondary education is somewhat short, his education corresponds to the conception category.

2. On the basis of the information available, the graduate from an industrial institute raises a problem that seems rather difficult to solve. One of the educational channels, the shortest, comprises only nine years' primary and secondary education, followed by four years at an industrial institute and a six-month practical training period in industry. This particular channel seems to fall short of the criteria for a career in liaison, but to be above those for execution. The graduate from an industrial institute would thus fall somewhere between the two categories. However, it should be borne in mind that the information available is incomplete.

3. It is interesting to note the many ways of gaining admission to industrial institutes, with or without an entrance examination. Similarly, it will be noted that there is no difficulty in switching from an industrial institute to a university.

Spain

Before the recent educational reform, the pattern of general education in Spain was as follows.

After four years' primary education the pupil had a choice between the following two streams of secondary education. (a) four years' lower secondary education and two years' higher general secondary education, leading to the *bachillerato general*, (b) five years' lower secondary education and two years' higher secondary education of a more technical character, leading to the *bachillerato laboral.*

The holder of the *bachillerato general* was entitled to admission to a higher engineering school after a one-year pre-university course, a one-year selective course and a one-year initiation course (i.e. after thirteen years' primary, secondary and preparatory education) After five years he graduated from the higher engineering school with the diploma of engineer.

The same applied to the holder of the *bachillerato laboral*, who was entitled to admission to the same type of higher engineering school after a one-year preparatory course, a one year selection course and a one-year initiation course (i e. after fourteen years' primary, secondary and preparatory education).

A pupil having completed only the four-year cycle of lower general secondary education (i e. terminating two years before the *bachillerato general*) was entitled to admission to a middle-level technical school after a one-year preparatory course and a one year selection and technical initiation course (i.e. after ten years' primary, secondary and preparatory education). After three years he graduated from the school with the diploma of *perito industrial.*

This diploma in turn gave access, after a one-year qualifying course, to a higher engineering school which provided a five-year educational course for engineers.

Since the recent educational reform, Spain has no longer a *bachillerato general* or a *bachillerato laboral*, but a single secondary-school leaving certificate. Possession of this certificate and a pass in the one-year university orientation course constitute the entrance requirement for *either* a faculty or higher engineering school providing a five-year educational course for senior engineers (a first cycle lasting three years devoted to basic sciences, and a second cycle lasting two years devoted to specialization), *or* a school providing a single-cycle three-year course for the education of industrial technician engineers.

All Spanish engineers, except for those in government employment, must belong to colleges of engineers coming under the corresponding technical ministries (public works, agriculture, industry, etc.).

Educational regulations, exemptions and the recognition of diplomas are governed by the State. All schools, both State and private are subject to the regulations in force for State schools.

Following the recent educational reform new curricula were drawn up and will be introduced first in schools for industrial technician engineers and secondly (1973/74), in faculties and higher engineering schools.

Each university establishes its own knowledge checking methods and the structure of its programmes and teaching and research systems. It supervises those university centres in its region which do not come under the State.

The general supervision of education is effected by the National Council of Universities, an advisory body, chaired by the Minister of Education and Science, which co-ordinates university activities.

Practical training, the updating of knowledge, reconversion when necessary to another special branch, and further education are entrusted to higher vocational education centres which form part of the universities.

Each university has a *patronato* responsible for relations with society as a whole. In the case of technical universities, industry and professional associations are represented on the *patronato*, which has as one of its objectives the definition of the role of industry in the education of engineers.

Completion of the first three-year cycle of the educational course for senior engineers, combined with some self-education, qualifies students for the diploma of industrial technician engineer.

Conversely, industrial technician engineers can be admitted under certain conditions to the second two year cycle of the educational course for senior engineers.

The information above calls for the following comments

1 Engineers (as they used to be called) and senior engineers (as they are now called) belong to the conception category.

2 The former *perito industrial* met the criteria for execution technicians.

3 Industrial technician engineers (as they are now called) meet the criteria for liaison technologists.

4 It will be noted that Spain seems to have solved relatively easily the question of promotion from the qualification of industrial technician engineer to that of senior engineer.

Sweden

Since its reorganization in 1962, the pattern of primary and secondary education is as follows: a nine-year course at a *grundskola* corresponding to primary education and lower secondary education, thereafter, higher secondary education of various types, provided at a *gymnasium*, lasting three years and leading to the *studentexamen*

Certain technical streams lead to a *teknisk hogskola*, a school at university level which awards the degree of civil engineer.

Secondary education may also be followed by a fourth year of study, and practical training periods in industry leading to the diploma of *gymnasieingenjor*.

Lastly, education at a *grundskola* may also lead to a *fackskola*, a special school providing a two-year course which must be accompanied by a practical training period of at least nine months, taken either before or after the two-year course, or between the first and second years of the course.

Each year Parliament determines the number of places available in each of the types of secondary education. Where the number of candidates exceeds the number of places available—and only in this event—entrance is by competitive examination.

In Sweden, training for civil engineers consists, on completion of secondary education, of a four-year course at a university or institute of technology, followed by a four-month practical training period and a terminal project.

The institutes of technology of Stockholm and Gothenburg (Chalmers) and the Engineering Faculty of Lund University all have the following six special subjects technological physics, mechanical engineering, electrical engineering, civil engineering, architecture, chemical engineering

The Stockholm Institute of Technology has, moreover, the following three additional special subjects aeronautics mining and metallurgy, geodesy and topography

Since 1969/70 the Engineering Faculty of the University of Linköping has been training engineers in the following three special subjects. technological physics and electrical engineering, mechanical engineering, industrial production.

Since 1971/72 the Luleå Institute of Technology, in the north, has been educating mechanical engineers, and since 1972/73 geotechnical engineers.

Lastly, the Science Faculty of the University of Uppsala trains engineers in technological physics.

Generally, the qualification of engineer is not protected by Swedish law, and prosecutions involve only those making use of an established qualification to which they have no right.

The ministry responsible for education is the Ministry of Education with, in the case of universities and institutes of technology, the Office of the Chancellor of the Swedish Universities.

Higher education is generally under the authority of the State. General curricula are drawn up by the State and serve as a basis for local curricula.

There is a regulation to the effect that examinations taken previously at universities in other Scandinavian countries shall be taken into account.

The above information calls for the following comments

1. The Swedish civil engineer meets the qualifying standards for the conception category
2. The *gymnasieningenjor* who has completed primary school and lower secondary education at a *grundskola*, lasting in all nine years, followed by four years technical education and practical training at a *gymnasium*, is less qualified than a liaison technologist but more qualified than an execution technician The *gymnasieningenjor* raises a difficult problem of classification, justifying a more thorough study of the real content of his education (cf the case of Portugal).
3. A *fackskola* diploma does not comply formally with the qualifications of an execution technician, but it may nevertheless be assumed that it is on these lines.
4. It will be noted that there is a trend towards annual quantitative planning at the level of higher secondary education.
5. Lastly, it will be noted that there are multi-national agreements with the other Scandinavian countries for the mutual recognition of diplomas.

Switzerland

The three categories of professional technologists to be considered in Switzerland are as follows

Graduate engineers

After the secondary-school leaving certificate, engineers are educated in one of the two federal polytechnics (Zurich and Lausanne), which come under federal authority, or the universities of Geneva and Neuchâtel which come under the authority of cantons.

In the federal polytechnics, the course lasts four years, the first two years being devoted to basic scientific and technical training (mathematics, mechanics, analysis, the use of computers, etc), while the next two years consist of more advanced education with a specific vocational bias Students also have the possibility of concentrating on a very closely defined special field.

For example, the Zurich polytechnic has the following thirteen sections, architecture, civil engineering, mechanical engineering, electrical engineering, chemical engineering, pharmacy, forestry, agriculture, agricultural engineering and topography, mathematical and physical sciences, natural sciences (with three subdivisions. biology, chemistry, physics, crystallography, biochemistry and microbiology, earth sciences (geology, petrography, geophysics, geography)), military sciences, free subjects

Except for the last two sections, the duration of the course is four years. It is followed by compulsory practical training periods, lasting eighteen months for pharmacy, thirteen months for forestry, twelve months for architecture and agriculture and six months for mechanical engineering and electrical engineering.

Technician engineers graduating from higher technical colleges (ETS)

Basic education at present takes one of the following two forms on completion of nine years' compulsory education ending at the age of 16 years *either* four years at a vocational school *or* four years apprenticeship.

A study is currently being conducted for the introduction of a technical secondary-school leaving certificate

After this preliminary education, the future technician engineer takes an entrance examination for a higher technical college, where the course lasts three years, plus a semester for the preparation of a terminal thesis. Alternatively, technician engineers can be educated by attending evening classes at the same colleges for fifteen to twenty hours a week during five years

Technicians

Technicians are educated in private schools, and through the programme for social and vocational advancement of skilled workers. After nine years' compulsory education, a technician may choose one of the following forms of education and training *either* four years' apprenticeship in a school or a firm, followed by a four- or five-year part-time course at an evening school (*technikum*), *or* three or four years apprenticeship, followed by a one-and-a-half-year course in a specialized vocational school, *or* three to five years practical training, followed by a one-year full-time course preparing for the diploma examination

The federal law on vocational education regulates the diplomas awarded by the higher technical colleges (ETS)

A register of engineers, architects and technicians was set up in 1951 to regulate the use of professional designations and to list all Swiss technologists including technicians. The training acquired by non-graduates was inspected by an *ad hoc* commission.

In 1966 the register bacame the Fondation des Registres Suisses (REG), responsible for keeping registers for the following categories. engineers and architects, technician engineers and technician architects, and technicians. The foundation is a private professional institution [1]

The holders of diplomas awarded by recognized establishments may be enrolled, simply by so requesting, on the corresponding register.

The two federal polytechnics of Zurich and Lausanne come under the federal Department of the Interior, whereas the eight universities of Geneva, Lausanne, Fribourg, Neuchâtel, Berne, Basle, Zurich and St Gallen come under their respective cantonal governments and, generally speaking, under their departments of education Both types of institution enjoy fairly wide autonomy Polytechnics are placed under the supervision of the Schools Council which maintains liaison between the federal government and the heads of schools The Confederation makes grants to cantonal universities.

1 Affiliated to the register in 1951 were two professional associations the Society of Engineers and Architects (SIA) and the Union Technique Suisse (UTS) whose members had been trained at a *technikum* a type of school existing at the time but subsequently changed to technical colleges awarding the degree of technician engineer The translation of *ingénieur technicien* into German as *Ingenieur Techniker* and not as *Technische Ingenieur* displeased the holders of this qualification with the result that UTS refused to join the Fondation des Registres in 1966.

In the case of polytechnics, curricula are drawn up by their various faculties or sections, and are approved by the Schools Council, which also supervises their application

The detailed curricula are drawn up by the Conference of Faculties, consisting of professors, lecturers, assistants and, more recently, students as well. The eighteen higher technical colleges (ETS) receive substantial grants from the confederation. They are, however, cantonal and come under the supervision of the appropriate cantonal department, but the federal government lays down requirements as to curricula and co-ordination between schools. The curricula are drawn up by the cantonal authorities in agreement with the Office Fédéral de l'Industrie, des Arts et Métiers et du Travail (OFIAMT), the federal department of vocational education.

Industry is represented on the various supervisory councils and commissions in addition, a large number of teachers come from industry, which finances part of the research work conducted in research institutes and stations.

The fact that students from higher technical colleges (ETS) have often spent four years on practical training in industry gives industry a *de facto* role in the education provided by technical colleges

Industry participates actively in continuing education and the organization of practical training periods. Both self-educated technologists and middle-level staff may apply to be enrolled on higher registers by giving proof of their ability in an examination. Continuing education is organized either by schools, professional associations or industry.

Technician engineers from higher technical colleges (ETS) are entitled to enter polytechnics on passing an examination in general education

As the Société des Ingénieurs et Architectes includes both engineers and architects, there is virtually no distinction between architects and civil engineers.

In the polytechnics, engineers are educated to solve interdisciplinary problems and to direct operations. In the higher technical colleges, education is more specialized and is oriented to a larger extent towards practical work.

On graduating, engineers and architects are concerned with interdisciplinary problems such as land development and the environment in general.

United Kingdom

Secondary education in the United Kingdom comprises subjects for which the GCE (General Certificate of Education) examination can be taken at the ordinary level (O-level), around the age of 16, and at the advanced level (A-level) around the age of 18 to 19

The theoretical education of a chartered engineer may be acquired in one of the five following ways

1 A scientific secondary education, comprising three O-levels and two A-levels or one O level and three A-levels, followed by a three-year full-time course or a four-year sandwich course (alternating with periods of practical experience in industry) in applied science at a university.

2 A scientific secondary education, comprising three O-levels and two A-levels, followed by a four-year sandwich course in applied science taken at a polytechnic

3 A scientific secondary education, comprising four O-levels and one A-level, followed by a three-year sandwich course taken at a polytechnic or certain other colleges, leading to the Higher National Diploma, which is then followed by at least one year's full-time preparation for the second part of the examination of the Council of Engineering Institutions (CEI).

4 A technical secondary education, comprising four O-levels, followed by a two year part-time course provided by a number of colleges, leading to the Ordinary National Certificate, which is then followed by *either* a two-year part-time course leading to the Higher National Certificate, plus at least one year's full-time preparation for the second part of the CEI examination, *or* preparation for the first part of the CEI examination, and then at least one year's full-time preparation for the second part of the CEI examination

5 A technical secondary education, comprising three O-levels, followed by a three year part time course provided by a number of colleges, leading to the City and Guilds Certificate, which is then followed by a one-year part-time course leading to the City and Guilds Full Technological Certificate, and thereafter by preparation for the first part of the CEI examination and at least one year's full-time preparation for the second part of the CEI examination.

Legal entitlement to the qualification of chartered engineer (C.Eng.) is also conditional on practical training and the holding of a responsible appointment for a minimum period of three years.

The theoretical education of a technician engineer may be acquired after a secondary technical education comprising three O-levels, followed by three years' part-time study at one of a number of colleges, leading to the City and Guilds Certificate which is then followed by one year's part-time study leading to the City and Guilds Full Technological Certificate.

Legal entitlement to the qualification of technician engineer (T.Eng.-CEI), is also conditional on five years' professional practice, including two years practical training in accordance with an approved curriculum.

The theoretical education of a technician may be acquired in one of the following ways:

1 A scientific secondary education, comprising four O-levels, followed by a two year sandwich course taken at one of a number of colleges, and leading to the Ordinary National Diploma

2 A technical secondary education, comprising four O-levels, followed by two years' part-time study at one of a number of colleges, leading to the Ordinary National Certificate

3 A technical secondary education, comprising three O-levels, followed by three years' part time study at one of a number of colleges, leading to the City and Guilds Certificate

Legal entitlement to the qualification of technician is also conditional on

three years professional practice, including two years of practical training in accordance with an approved curriculum.

The essential difference between university and polytechnic courses of future chartered engineers is that university courses consist mainly of theory and projects (practical training comes later during employment), whereas at polytechnics, on the contrary, the theoretical education given is immediately put into practice, and thus practical training takes place during the course.

The institutions affiliated to the CEI have a supervisory role as regards the basic practical training of their future members, who are already graduates. This basic practical training varies in importance from one branch to another of the profession, but all the institutions agree that it should be as broad as possible.

As regards updating of knowledge, the institutions affiliated to the CEI organize a large number of refresher courses. With regard to qualifying for another special branch, an engineer may be a member of several institutions simultaneously, knowledge of the new branch may be acquired through practice and/or through continuing education. In addition to the traditional pattern of continuing education provided by the institutions affiliated to CEI, four 'open universities' were set up in January 1971 and have already enrolled over 30,000 students

Continuing education—so closely associated with education as a whole that it is difficult to distinguish between initial education and continuing education as such—is largely facilitated by the general attitude of industry. 'Day releases' (corresponding to one working day) and 'block releases' (exceeding one working day) considerably facilitate continuing education in the form of sandwich courses (courses alternating with practical training in industry) Each year more than a third of the new Chartered engineers qualify through continuing education combined with their professional activity.

In the United Kingdom, there are a number of industrial training boards, including the Engineering Industrial Training Board. The CEI provides a link between the individual engineering institutions and these training boards, many of which are concerned with one more particular engineering field. This link is maintained at the local level by individual arrangements made between training institutions and educational establishments on the one hand and firms on the other hand, for example, a polytechnic will contact firms in its region, to find out which of them are willing to take students for the practical part of their education and training. The matter is largely one of supply and demand

The legal qualifications of chartered engineer (C Eng), technician engineer (T Eng.-CEI) and technician (Techn.-CEI) are obtained by entry in the national register of the Engineers Registration Board (ERB) which is managed by the CEI Membership of this register is subject to the terms of the Royal Charter granted to the CEI in its present form in 1971.

The criteria for entry in the three categories of the ERB register are as follows

For chartered engineers (C.Eng)

1. Minimum age 25.
2. A pass mark in the examination in applied science held by the CEI in accordance with the council's regulations or a pass in any other university examination or test accepted by the CEI as being of at least equivalent level (the university level of the examinations and tests held or accepted by the CEI is not less than that of the Degree in Engineering).
3. Practical training in the engineering profession, or functions which make it possible to acquire such training, meeting the practical training criteria established by the CEI member institution and complying with the general principles adopted by the CEI.
4. At least two years' experience in a post considered by the CEI member institution to entail professional responsibility, provided that the total sum of the period of this professional experience and the period of practical training referred to above is not less than three years.

For technician engineers (T.Eng.-CEI)

1. Minimum age: 23.
2. Academic qualifications at a level at least equivalent to that of the Ordinary National Certificate of The City and Guilds Part II/Final Technicians' Certificate, and approved by the Office of the ERB and the CEI (unless otherwise decided by the Office and the CEI).
3. Five years minimum practical training and experience in the engineering profession, two of which must have been spent on practical training, both experience and training to be recognized by the Office of the ERB and the CEI.

For technicians (Techn.-CEI)

1. Minimum age: 21.
2. Academic qualifications at a level at least equivalent to that of the Ordinary National Certificate or the City and Guilds Part II / Final Technicians' Certificate, and approved by the Office of the ERB and the CEI (unless otherwise decided by the Office and the CEI).
3. A minimum of three years practical training and experience in the technical field, two years of which should have been spent on practical training recognized by the Office of the ERB and the CEI.

Educational policy at the universities, polytechnics and other colleges is the responsibility of the Department of Education and Science. The universities are fairly independent of the central authorities, the main tie being a financial one, though not always a direct one. For example, there is a University Grants Council, responsible to the Department of Education and Science, which supervises the financing of universities, without the latter being directly responsible to the department on that account.

Curricula are not laid down in detail, the main control being on the level of education and competence, both academic and practical, which is acquired. General supervision of education is ensured by the Department of Education and Science

In the United Kingdom there is no legal dividing-line between the professions of engineer and architect, although there are different functions which only one or the other can undertake. For example, the building of reservoirs and dams can only be undertaken by engineers who are on a special register. In the building industry, contracts are drawn up either by the Institute of Civil Engineers or by the Royal Institute of British Architects, depending on the type of contract.

The somewhat singular situation which exists in the United Kingdom calls for the following comments.

1. A remarkable difference of approach will be noted between the British system and the Continental-type system, particularly as regards.
   (a) The fact that a degree obtained at an educational institution, such as a university, does not automatically confer the right to use a professional title, besides the degree, practical training and the holding of a post of responsibility for a fairly long time are required.
   (b) The many different ways of entering the profession.
   (c) The considerable development of continuing education, which is closely interwoven with the educational system in general.
   (d) The legal role of the CEI, a more or less private institution, in the awarding of professional qualifications.
2. The scientific secondary education of a chartered engineer referred to above completed at the age of 18 to 19 may be assimilated to the corresponding Continental education The chartered engineer must then obtain a university degree, either after a three-year full-time course or by means of sandwich courses spread over four years, and thereafter must first undergo a basic practical training and then hold a post of responsibility for a period of at least three years. Although there is no formal correspondence between this type of training and the criteria for the conception category, it is reasonable to assimilate it thereto.
3. Similarly, the technician engineer can be assimilated to a liaison technologist and the technician to an execution technician.